The Journal of HEREDITY

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Effects of Temperature and Light on Growth

Parallel Color-Variations in Cats and Rabbits

The Living and the Non-Living

Inbreeding Swine

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COMING

Terrapin Hybrids

The breeder of turtles must have a tree-breeder's patience. He must wait four years before he can even begin his experiments, and it takes even longer than that for the young turtles to reach maturity. Hundreds of generations of fruit flies could be raised in the same time, so *Drosophila* will probably not give way to the champion of the soup-kettle as the basic tool of genetic research.

Waxy Starch in Sorghum

The waxy form of maize has been studied for many years. Like waxy rice, millet and maize, this new form comes also from the Orient. Why should all of these parallel mutations in so many different genera have all appeared in the same quarter of the world?

Inheritance of Metabolic Diseases

Diabetes is perhaps the best known metabolic disease, but it is by no means the only one. What part does heredity play in these deviations from normal body chemistry?

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HEADING-TIME HALVED BY CHILLING

Frontispiece

Harvest Queen winter wheat grown in a greenhouse at 55 to 65° F., with the full winter daylight and light from a tungsten lamp (25 foot candles at the soil line) from sunset to 10:30 p. m. daily. The plants on the left were from germinated seeds chilled at 30 to 35° F. in the dark for 67 days. Those on the right were from unchilled seeds germinated to a point equal to that of the chilled seedlings at room temperature just before all the seedlings were placed in the greenhouse. The plants from chilled and unchilled seeds headed 66 days and 128 days, respectively, after planting.

EARLINESS AND SEASONAL GROWTH HABIT IN WHEAT

As Influenced by Temperature and Photoperiodism

H. H. McKINNEY and W. J. SANDO*
Division of Cereal Crops and Diseases, United States Department of Agriculture

DURING recent years plant breeders in the United States have been making practical use of Garner and Allard's[1] findings on effect of length of day on plant development. By adjusting the length of the daily photoperiod it is possible to bring about sexual reproduction simultaneously in early and late types in several crop plants. In spring cereals it is also possible to obtain two generations in one year by growing the winter crop in a long day consisting of winter daylight and electric light, thus greatly facilitating hybridization and the increase of progenies.

Recently, reports of Russian work on the acceleration of sexual reproduction, the so-called "Iarovization" of plants, have attracted considerable attention in the United States.† Owing particularly to interest in this method as it applies to winter wheat, the writers have been requested to summarize their own work, as well as certain early American work, on the acceleration of sexual reproduction (earliness) in wheat.

Earliness and seasonal growth habit will be considered from a rather broad point of view. Several methods for inducing earliness of sexual reproduction in wheats will be discussed, together with certain plant characteristics that it is thought play a part in determining earliness and seasonal growth habit.

In the present work the effects of environment are based to a large extent on the time of heading which in the varieties used preceded fertilization from two to five days.

Inducing Earliness in Certain Types of Wheat by Chilling the Germinated Seed or Seedlings

The earliest work on the chilling of germinated wheat seeds that has come to the attention of the writers is that of Klippart[3], an American investigator in Ohio, who obtained his results previous to 1857. Apparently this work has been unknown to all recent workers who have studied this problem, and, because of the historical interest the following is quoted from Klippart:

> To convert winter into spring wheat, nothing more is necessary than that the winter wheat should be allowed to germinate slightly in the fall or winter, but kept from vegetation by a low temperature or freezing, until it can be sown in the spring. This is usually done by soaking and sprouting the seed, and freezing it while in this state and keeping it frozen until the season for spring sowing has arrived. Only two things seem requisite, germination and freezing. It is probable, that winter wheat sown in the fall, so late as only to germinate in the earth, without coming up, would produce a grain which would be a spring wheat if sown in April instead of September. The experiment of converting winter wheat into spring wheat, has met with great success. It retains many of its primitive winter wheat qualities, and produces at the rate of 28 bushels per acre.

When the autumn sowing is delayed temperatures sometimes drop very quickly, preventing the emergence of the seedlings until the following spring. If there is enough moisture during the winter to start germination the resulting plants will produce a satisfactory commercial crop the following spring. This has been observed for many years in the Pacific Northwest and in parts of the

* Senior pathologist and associate agronomist, respectively.

† A brief summary of this work was given in the preceding issue of the JOURNAL (Page 165). References are given there to other Russian publications on this subject.

Southwest. The writers of this paper have observed this relationship independently in date-of-seeding nurseries at the Arlington Experiment Farm (near Washington, D. C.). The senior writer observed the phenomenon in 1920 in date-of-seeding nurseries at Granite City, Ill., and stated that it seemed evident that "the effect of soil temperatures in relation to the stages of plant development is largely responsible."[5].

The studies of the writers on the chilling of germinated seeds were started without knowledge of the early American work, though it was known that German investigators had studied the effects of low temperatures on older seedlings. In 1924 the junior writer conducted an experiment with germinated winter-wheat seed held in a dark chamber for various periods up to six days at temperatures of 24, 32, and 40° F., respectively. However, none of these treatments was of sufficient duration to accelerate heading.

The results of the writers' first test in 1928-29 have been briefly summarized[6]. Typical plants from a part of this test are illustrated in the Frontispiece. The seeds of Harvest Queen winter wheat were moistened and as soon as the plumules burst the pericarp tissue they were placed in a dark, mechanical refrigerator with the temperature ranging from 30 to 35° F. After 67 days at this temperature range the germinated seeds were planted in pots of soil in a greenhouse at 55 to 65° F. with full winter daylight and light from a Mazda tungsten lamp (25 foot candles at the soil line) from sunset to 10:30 p. m. daily. The duration of the daily photoperiod ranged from 16 to 18 hours. The unchilled seeds were germinated at room temperature until they reached the same stage of germination as that of the chilled seedlings. Plants from these seeds were used as controls.

Plants from the chilled seeds headed 66 days after planting, whereas plants from the unchilled seeds did not head until 128 days after planting.

Germinated wheat seeds and seedlings have been chilled at different temperatures, as indicated in Table I. These data show that tempera-

TABLE I.—Number of days from the end of the chilling treatment to heading in three winter varieties and in Marquis and Prelude, spring wheats. Seedlings were chilled 65 days in the dark at different temperatures. After chilling, the plants were grown in a greenhouse with uninterrupted light at 70 to 75° F. at night. During the day temperatures went above 75° F., especially when the sun was bright. The chilling treatment terminated March 2, 1932.

Variety	Number of Days from End of Chilling to Heading				
	30 to 35°F.	37 to 39°F.	39 to 41°F.	42 to 44°F.	No chilling
Harvest Queen	43[a]	39	39	42	....[b]
Currell	53	39	39	45	....[b]
Sol	109	52	52	56	....[b]
Marquis	35	42	42	47	35
Prelude	33	39	39	43	31

[a] Corrections were made in heading times to allow for differences in the development of the seedlings held at the different chilling temperatures at the time chilling was discontinued. The time comparisons were computed from plumules one-sixteenth of an inch in length.

[b] No heading at the end of 140 days.

tures from 37 to 44° F. were more favorable than the lower temperatures for stimulating earliness in the winter varieties tested. Sol and Currell varieties were especially favored by the temperatures above 35° F. However, the advantage became less at 42 to 44° F.

The low temperatures retarded earliness in Prelude and Marquis spring wheats. Other tests show that the heading time is reduced six days in Kinney, a late spring wheat, when the germinated seeds are chilled at from 37 to 39° F. for 28 days and the subsequent plants are grown at summer temperatures in continuous light.

The influences of the duration of chilling, temperature, and daily photoperiods subsequent to chilling are shown in Table II for several varieties.

It will be noted that more varieties failed to head at 70 to 90° F. in a natural day than at the lower outdoor temperatures with a natural day, and the number of failures were least with uninterrupted light at the outdoor temperatures. It is evident from these data that the proper time required for chilling the germinated seed will be determined not only by the characteristics of the variety but also by the temperature and light

TABLE II.—Influence of different growing conditions on the time in days from the end of the chilling period to heading. Slightly germinated seeds of the varieties were chilled in the dark at 30 to 35° F. for different periods. Plants from unchilled seedlings were grown for comparison. Plantings made April 18, 1932, at the Arlington Experiment Farm, Rosslyn, Va.

Variety	C.I. No.[a]	Growing conditions after chilling											
		24-hour day outdoors				Natural day outdoors[b]				Natural day in greenhouse 70 to 90°F.[c]			
		Number days chilled				Number days chilled				Number days chilled			
		80	65	40	0	80	65	40	0	80	65	40	0
Hybrid "X"[d]		39	40	47	0[e]	53	51	67	0	40	42	132	115
Turkey	1558	46	47	50	0	69	73	79	0	63	89	0	0
Kanred	5146	45	49	51	0	63	70	0	0	55	72	0	0
Minhardi	5149	47	48	77	0	72	82	0	0	0	0	0	0
Minturki	6150	46	48	52	0	66	69	0	0	62	0	0	0
Buffum 17	3330	50	51	59	0	0	0	0	0	123	0	0	0
Odessa	4475	48	47	67	0	66	84	0	0	89	108	0	0
Rudy	6465	43	45	49	0	61	63	80	0	55	61	0	0
Harvest Queen	Sel.	44	43	47	0	59	59	74	0	51	56	0	0
Sol	6009	43	53	0	0	0	0	0	0	0	0	0	0
Currell	3326	43	46	60	0	61	69	0	0	55	146	0	0
Purplestraw	1915	46	46	51	75	65	63	64	0	52	52	75	77
Oakley	6301	41	41	44	0	60	56	71	0	51	49	95	112
Spelt	1772	42	43	46	47	51	65	71	78	59	59	67	69
Marquis	3041	..	..	..	42	..	..	..	60	..	..	..	56

[a] C. I. denotes accession number of the Division of Cereal Crops and Diseases, formerly Office of Cereal Investigations.

[b] The mean temperatures outdoors for April, May, June, and July were 52.6, 64.2, 73.2, and 77.4° F., respectively. The departures of the daily maximum and daily minimum temperatures from the mean temperatures averaged near 10° for these months.

[c] At night and on dark days the temperature in the greenhouse was controlled between 70 to 75° F. until May 10 when the steam was turned off. The temperatures at midday averaged 90°.

[d] This wheat came to the senior writer unnamed from the Kansas Agricultural Experiment Station. It is said to be from a cross between Kanred and Hard Federation. It has the beak of Kanred and the chaff is white. It was of particular interest because of its extreme earliness in the mosaic-disease nursery at the Arlington farm and because it gave evidence of having a rather extreme low-temperature requirement during its initial growth phase for earliness.

[e] Zeros indicate that no heading occurred during the summer.

conditions that obtain during the subsequent growing period.

Practical Applications

From these results it appears that the lower temperatures and longer days that prevail in Russia may be more favorable for the use of spring-sown chilled (iarovized) winter wheat, especially certain varieties, than the higher temperatures and shorter days obtaining in the principal winter-wheat areas of the United States. So far as the United States is concerned it remains to be demonstrated that spring-sown chilled winter wheats have any advantage over suitable spring wheats in the cropping system.

By chilling germinated winter-wheat seeds it is possible for the plant breeder to study spring-sown winter varieties and spring varieties simultaneously in northern regions where winter wheats cannot be grown when fall sown. It is also possible to obtain two or more generations of winter wheat in one year, depending on the characteristics of the genotype. In practice the method has been used to advantage in producing one crop of winter wheat outdoors and a second crop in a greenhouse. Germinated seed is chilled at 37 to 39° F. for 50 to 65 days preparatory to sowing early in the spring. Seed from the resulting field crop is germinated and chilled. The plants from these chilled seedlings are then managed so as to avoid heading during the shortest days of the year, as low light intensity frequently induces sterility even when the days are lengthened by means of Mazda tungsten lamps. The seed from this crop may be germinated and sown in the field in regions of moderate winters before February 15, or it may be germinated and chilled in a refrigerator preparatory to sowing in the field in the spring.

When small numbers of seeds are being treated they may be germinated and placed in damp soil. At 37 to 39° F. the plumules may become 2 or 3 inches long when held for 50 to 65 days in darkness, but on transplanting in the light they become green and develop into strong plants. When large numbers of seeds are being handled it is not practicable to transplant seedlings. In this case it is advantageous to retard germination during the chilling treatment. This is accomplished by maintaining the moisture content of the seed near 50 per cent of the dry weight of the seed It has been found more satisfactory to soak the seed in an excess of water until it is soft, than to add only the quantity of water necessary to bring the moisture content up to the required percentage as recommended in the Russian methods. An excess of water seems to reduce some of the irregularities in germination.

Six to twelve hours soaking is sufficient for most hard-seeded varieties, but less time is required for the soft-seeded types. When soaking several bushels of seed on a floor, the water may be applied several times in order that the seed may be kept wet, the excess water being allowed to drain away. The pile should be covered with a canvas. Small lots of seed can be soaked in an excess of water in a container. After soaking, all the water is drained off and the damp seed allowed to germinate slightly at 60 to 75° F.; 65 to 70° F. has been found practical. When the early stages of germination are evident in the majority of seeds, the seed is spread out in a thin layer to dry to 50 to 55 per cent moisture. During the drying process the seed should be shoveled or stirred, depending on the quantity. Fans hasten the drying process.

Combining Temperature with Light During the Initial Growth Phase to Control Earliness

Although the method of chilling winter-wheat seed in darkness has its

* When chilling quantities of seed as great as a peck or more, care must be exercised to avoid too much rise in temperature due to the heat of respiration. Shallow boxes or bins 3 to 4 inches deep have been found better than grain sacks for containing the seed during the

value, it also has its limitations. Many investigations on the adaptation of the wheat plant, and on the expression of characters in physiologic, genetic, and breeding work must be conducted in the light during the initial growth phases when low temperatures obtain. Temperature is a major factor in controlling earliness in wheat, especially in winter wheats chilled in the dark, but the writers cannot take the view of Lysenko[4] that temperature is the primary controlling environmental factor in earliness under field conditions.

Wanser[7] was the first to point out the importance of photoperiodism in the acclimatization of wheat. His studies, those of Garner and Allard,[2] and many others show clearly that the length of the daily photoperiod is of major importance in controlling earliness. Studies previously summarized[6] and which will be published in full later show that within limits temperature and the length of the daily photoperiod compensate for each other in their influence on earliness. Other factors such as light intensity and quality, soil fertility, etc., also influence earliness and they must be taken into account. However, temperature and the photoperiod appear to be the two major environmental factors which at present warrant concentrated effort in studies on earliness.

When sexual reproduction is accelerated very rapidly the yield of seed per plant is reduced owing to a reduction in the number of tillers and in the number of fertile florets per head. However, yields have been less when extreme earliness is induced in plants from germinated seeds chilled in the dark than when the plants were grown under suitable conditions of light and temperature during the initial growth phase.

Harvest Queen plants from seeds chilled for 40 days in darkness and grown with uninterrupted light at summer temperatures headed 89 days from the time the seed started to soak. This is the most rapid completion of the life cycle yet obtained in Harvest Queen winter wheat from chilled germinated seed. However, only 10 to 30 seeds per plant were produced.

Yields of 75 seeds per plant have been obtained in Harvest Queen when heading took place 88 days from the time the seed started to soak and when the seedlings and plants were grown according to the following schedule of temperatures, photoperiods, and times:

70 to 75° F. on moist filter paper for two days to start germination.
50° F. for 36 days with a photoperiod of eight hours in culture chamber.
60° F. for 18 days with a photoperiod of eight hours in culture chamber.
70 to 75° F. to end of test with a photoperiod of 18 hours in greenhouse.

These plants actually headed earlier than those from chilled seed and it is likely that still earlier heading is possible without reducing the yield to 30 seeds per plant.

Harvest Queen plants from chilled

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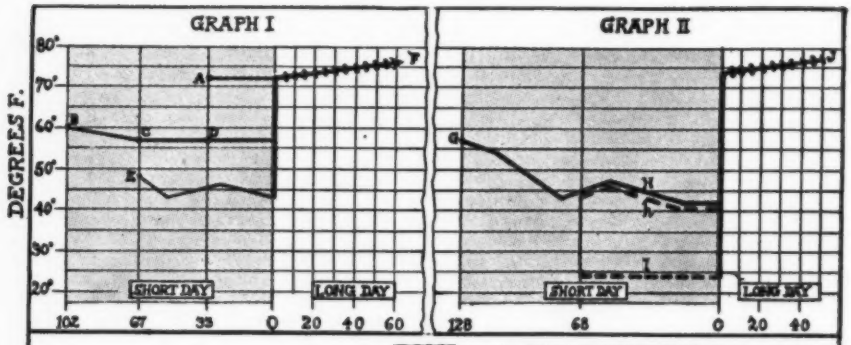
period of germination and the chilling treatment. Seed should be stirred several times while it is being chilled.

Smaller quantities of seed are handled in Mason fruit jars or in bottles throughout the soaking and chilling treatment. These containers should not be completely airtight and the moisture content of the seed should be watched to avoid undue loss of moisture during the chilling treatment. Some varieties and some lots of seed of the same variety germinate more rapidly than others at low temperatures. If germination proceeds too fast the seed should be freed from some of the water.

If germinated seed is to be drilled the plumules should not exceed one-thirty-second to one-sixteenth of an inch in length. Vigorous seeds with plumules one-sixteenth of an inch long can be dried and held for a short time if necessary, but if germination proceeds beyond this range irregularities and reduction in stand may result. When the plumules are broken further development is prevented in nearly all cases.

Seeds 12 days from fertilization have reacted to the chilling treatment as efficiently as mature seeds. Immature seeds are first germinated near 60° F.



Length of Daily Photoperiod
8 Hours
11-12 Hours
16-17 Hours

Variety	C.I. No.	Time in days from planting to heading for the environments designated by the alphabetical symbols. AF	BF	CF	DF	EF	GHJ	GhJ	GIJ
Red Winter spelt	1772	*74	76	102	133	113	164	164	168
Purplestraw	1915	95	*77	96	120	106	154	156	161
Currell	3526	130	*97	101	131	109	161	157	163
Harvest Queen	Sel.	130	103	*100	131	109	162	161	162
Turkey	e175	150	118	*106	136	113	165	164	166
Turkey	1558	152	137	*110	139	117	167	168	169
Kinhardi	5149	149	112	*107	135	117	162	163	167
Sol	6009	160	126	*118	145	134	177	170	177
Hybrid "K"		125	123	116	133	*106	156	153	156

EFFECT OF TEMPERATURE AND LIGHT

Figure 1

Combined graphs and table showing the influence of initial temperatures and of various lengths of the daily photoperiod on the expression of earliness in different varieties of wheat when all were subsequently allowed to grow at temperatures averaging above 70° F. with 16 to 17 hours of light daily. Seed was germinated but not chilled before sowing. The first seeding was made October 21, 1931.

Explanation of graphs.—Mean temperatures are represented by the curves. The length of the daily photoperiods are indicated by the construction of the curve lines as shown in the figure legend.

In graph I sowings were made 102, 67 and 33 days before the plants were subjected to high temperatures and long days. In graph II sowings were made on one date only. Sixty days after sowing the experiment was divided into three parts, each part being subjected to the temperatures and photoperiods indicated. All parts received the high temperatures and long days 128 days after sowing. The broken line (h) is separated from line (H) to show that two photoperiods were maintained. Line (H) represents the true mean temperature of line (h).

Explanation of tabulated data.—The alphabetical symbols in the column refer to the same letters on the graphs. These headings denote the temperature and photoperiodic curves during the period of the experiment for the plants that headed at the times in days listed in the columns. The number of days required for heading were calculated from the time of planting. The asterisks indicate the earliest heading date for each variety or hybrid.

germinated seeds will yield 75 seeds if grown at 70 to 75° F. with a daily photoperiod of 16 to 18 hours. However, 100 or more days are required for plants to head when computing time from the beginning of the soaking process.

Varieties show wide differences in their earliness reactions when the plants receive light daily during the period of low temperature. The tests cited in Figure 1 were conducted outdoors and in a greenhouse during the autumn and winter in order to test natural conditions.

It will be noted in Figure 1 that Red Winter spelt was the only variety to head earliest when grown at the higher temperatures throughout the life cycle, although heading was re-

tarded only two days when exposed to a mean temperature of 57° F. for 33 days. Other tests indicate that earliness in Red Winter spelt is favored by a relatively short duration of low temperature* in the seedling stage. Purpluestraw, a facultative variety, and Currell, a winter variety, were earliest when held near the 57° F. mean for 33 days. Harvest Queen, Turkey (C. I. No. 1558), Turkey (C. I. No. 6175), Minhardi, and Sol winter wheats all headed earliest when exposed to the 57° F. mean for 67 days. Hybrid "X" was the only type in the series in which early heading was favored by exposure to the lower temperatures of the outdoors, and this relationship has been maintained in later tests. This wheat has been one of the earliest at the Arlington farm and even though it has been favored by the lowest temperature yet encountered in the present work, its stem elongates phenomenally fast after the plants are exposed to the high temperatures and to a long photoperiod.

Exposure to the lowest temperature did not produce earlier heading in Minhardi than did the mean temperature of 57° F., although Minhardi is outstandingly resistant to low temperatures lethal to the majority of winter wheats, these temperatures seem not to benefit earliness. A similar relationship seems to obtain in Buffum 17, another very hardy wheat.

It will be noted in Figure 1 that none of the exposures exceeding 67 days favored early heading in any of the varieties, nor was heading hastened by exposure in chambers to a mean of 24° F.

The data in Table II suggest that Minhardi, Sol and Currell have relatively greater low-temperature requirements for earliness than do the data in Figure 1. It is believed these apparent inconsistencies can be explained on the basis that 30 to 35° F. is too far below the optimum in the case of these varieties as indicated for Sol and Currell in Table I.†

Although varieties of winter wheat differ in their temperature and length-of-day requirements for earliness, tests indicate that all the winter varieties tested complete their life cycles quite rapidly and produce good yields of seed when grown near 45 to 50° F. with a daily photoperiod of 8 to 10 hours for 43 days followed by temperatures near 70 to 75° F. with a daily photoperiod of 16 to 18 hours.

Exposure of 20 days to the low temperatures and short days has been satisfactory for the facultative varieties.

It will be observed in the tabular matter in Figure 1 that certain varieties and Hybrid "X" reversed their relative order of heading, as for example, Red Winter spelt and Purplestraw; Harvest Queen and Hybrid "X"; Minhardi and Hybrid "X". Reversals in the order of heading occur also among certain spring wheats such as Bunyip and Prelude. When the daily photoperiod was varied and temperatures were maintained near 70 to 75° F. the order of heading was as follows: Bunyip, 53 days earlier with an 8-hour day, and 16 days earlier with an 11-hour day. Heading was simultaneous in a 16-hour day. Prelude was 15 days earlier than Bunyip in continuous light. The order of heading in these varieties was reversed in the field at different stations; the phenomenon has been observed in other varieties by several workers in different parts of the world. Reversals

*In this paper 70° F. is taken as the dividing point in the range between low temperature and high temperature.

†It is not implied that the data in Figure 1 represent the exact relative temperature requirements during the initial growth phase of the varieties listed. The exact relationships can be determined only when tests include a larger number of temperatures and times of exposure to these temperatures.

seem to be tied up to a large extent with differences in the environment-response characteristics of the growth phases of the varieties.

Earliness characteristics of wheat varieties have been studied by several investigators in date-of-seeding experiments. By this method the effect of the total environmental complex is determined for different periods of the season or for the entire year. From such studies Lysenko[4] devised a formula by which he attempts to predict the heading date of a given variety when sown at any given time. However, since he considers that temperature is the controlling environmental factor in determining earliness, his formula can apply only to regions near the same latitude. To have wide application his formula should include factors for the influence of light. Date-of-seeding tests have value in making the first general comparisons between varieties and serve as the starting point for more detailed studies to determine the relative influence of the several factors in the environment.

Plant Characteristics Concerned in Earliness

Earliness of sexual reproduction appears to depend on the interrelation of several characters, each of which may be measured when suitable methods are developed. It seems reasonable to believe that the study of these characters separately and in suitable combinations should aid in furthering an understanding of earliness.

Under the conditions of the writer's tests the stems did not elongate appreciably while primordial leaves and internodes were forming. Therefore it is expected that rapid elongation of the stem will be delayed as the number of internodes per culm is increased. When grown with continuous light and also with 16 hours of light daily the spring wheats that produced the fewest internodes headed much earlier than those which produced the greatest number as shown in Table III. This relationship between internode number and earliness is reversed in some varieties that differ but slightly in internode number. Also Prelude and Early Defiance grown in continuous light and with a 16-hour day headed several days apart, though each produced the same number of internodes per culm.

These apparent inconsistencies seem to be due to other characters that influence earliness. Preliminary tests suggest that varieties have different growth-rate characteristics when growing under optimum conditions for the earliest sexual reproduction. For example, the growth rate of the stem of Prelude was double that of Kinney wheat when both were grown near 70 to 75° F. with continuous light.

It will be observed in Table III that environmental conditions tending to favor earliness tend also to favor a reduced number of internodes per culm, though it is clearly evident that several varieties that were earlier in continuous light than they were in the 16-hour day showed no change in the number of internodes under these light conditions. Also Bunyip, in the 8-hour day, produced 14 internodes, whereas Prelude produced only 11, yet Bunyip headed much earlier than Prelude. This relationship seems to be due very largely to extreme retardation in the growth rate of the apical stem internode (peduncle) of Prelude. When grown near 70 to 75° F. with an 8-hour day, stem elongation started a week earlier in Prelude than in Bunyip. The flag leaf of Prelude extruded completely, but the apical internode elongated much more slowly than the lower ones and as a result Bunyip was in full head 53 days before Prelude. Examination of Prelude at the time Bunyip headed showed that its apical internode was less than one-eighth of an inch long and the head but one-half of an inch long.

While the present studies have not dealt with exact temperature optima for the earliest sexual reproduction it seems evident from the data presented

that the temperature requirement for the most rapid completion of one growth phase or group of growth phases is not necessarily the same for another phase or group of phases of the same plant; also that the temperature requirement of a given growth phase or group of phases is not the same for all varieties. It seems reasonable to believe that these temperature-response characteristics of the growth phases are determined by internal mechanisms which constitute genetic characters, the inheritance of which seems to be more or less independent in the several growth phases of the plant. What has been said for temperature-response characteristics seems also to apply to the photoperiodic-response characteristics in winter wheats, but uninterrupted light seems to be optimum for the most rapid completion of all growth phases in some of the spring wheats.

Although these environmental-response mechanisms cannot be measured directly at the present time, it appears that they may be measured indirectly in terms of internode number, growth rate, and finally in time of sexual reproduction over a range of temperature and light conditions.

TABLE III.—Number of internodes per culm in spring wheats in relation to the time of heading in days.

Variety	Temperatures and length of daily photoperiod							
	[a] 57 to 93°F.						[b] 70 to 75°F	
	24 hours		16 hours		12 hours		8 hours	
	No. Ints.	Days Hdg.	No. Ints.	Days Hdg.	No. Ints.	Days Hdg.	No. Ints.	Days Hdg.
Prelude	5	32	5	32	5	43	11	140
Early Defiance	5	36	5	43	7	62	....	....
Reward	6	33	6	39	6	53	13	104
Quality	6	39	6	40	9	59	13	105
Haynes Bluestem	6	39	6	43	.....	....	.....	.....
Marquis	6	39	6	47	.....	....	17	170
Hard Federation	6	39	8	53	.....	....	14	142
Rink	6	40	6	43	.....	....	.....	.....
Humpback	6	41	6	50	.....	....	16	179
Hope	6	43	6	47	.....	....	.....	.....
Sonora	6	46	....	....	.....	....	14	154
Bunyip	7	43	7	47	.....	....	14	87
Baart	7	46	7	43	.....	....	12	148
Barnatka	7	48	8	63	.....	....	14	138
Touse	8	49	9	67	.....	....	.....	.....
Sevier	8	50	10	65	.....	....	17	165
Federation	8	57	9	76	.....	....	14	144
Bluechaff	8	67	10	83	.....	....	.....	.....
New Zealand	9	58	10	67	.....	....	15	201
Kinney	10	62	10	76	.....	....	18	181
Pacific Bluestem	10	65	9	67	.....	....	.....	.....
Jenkin Club	11	81	13	94	.....	....	.....	.....

Note: The number of internodes was determined by an accurate count of all the leaves, not including the coleoptile, on the primary stalk. The leaves were carefully marked during the process of growth to avoid errors in counting.

[a] Grown outdoors during midsummer.

[b] Grown in a greenhouse during the autumn, winter, and spring. Temperatures sometimes went above 75° F. on bright days.

Discussion and Conclusions

Important information on earliness in sexual reproduction can be obtained in many wheat varieties by dividing the life cycle of the plant into but two major growth phases and by determining their environmental characteristics. It seems likely, however, that a better understanding of earliness will result when the environmental characteristics are determined for a greater number of growth phases. Observations suggest that germination, the appearance of each of the leaves and the head, fertilization, and seed development may be considered roughly as indicators of the growth phases.

From the studies on seasonal growth habit it appears that wheat varieties should be classed for this characteristic largely on the basis of their respective optimum temperature and length-of-day requirements for the earliest sexual reproduction possible in the variety. The terms "winter" and "spring" are used from the equator to the southern and northern limits of wheat culture and therefore do not represent definite temperatures or lengths of the daily photoperiod. They are relative terms and their value is largely provincial.

The typical spring wheats have relatively high-temperature and long-daylight optima during their entire life cycle, whereas the typical winter wheats have low-temperature and short-daylight optima during the initial growth phase and relatively high-temperature and long-daylight optima in the subsequent phases with respect to earliness. The low-temperature requirements of the initial growth phase of the winter group with an exposure of 43 days and with a day eight to ten hours long appears to range from near 38 to 60° F.

A winter wheat when sown in the spring in most spring-wheat areas does not receive optimum temperature and light conditions during its initial growth phase, thus causing a degree of lateness which prevents heading or seed production before winter sets in. However, if the season were sufficiently long, and the temperatures not too high, such plants should produce seed even though the plants received no low temperatures or short days durtheir intial growth phase. This has been demonstrated by bringing such plants into the greenhouse in the late summer and by continuous culture in the greenhouse. On account of these relationships it is concluded *that seasonal growth habit is a phase of earliness and lateness.*

In addition to the low-temperature requirements of winter wheats for earliness, this group also differs from the spring group in resistance to subfreezing temperatures during the winter. There is no evidence, however, indicating that the exceedingly low temperatures which such vareties as Minhardi can survive are of specific value in stimulating earliness.

On the basis of the extreme reversals in the order of heading in certain pairs of varieties when grown in different environments, for example Bunyip and Prelude, it is concluded that segregating populations from certain parent crosses will not give constant segregating ratios for earliness under all conditions of temperature and day length. This is also to be expected on the basis of the conclusion that earliness is influenced by several characters. It is concluded, therefore, *that populations which are segregating for earliness and lateness should be tested and classified as far as practicable under several suitable conditions of temperature and day length.* This should facilitate the selection of genotypes homozygous for the several characters influencing earliness and lateness. Such types will have far greater value than most of the existing types for making detailed genetical, environmental, and biochemical studies and interpretations.

Summary

Sexual reproduction can be greatly accelerated in winter wheats by first subjecting the slightly germinated

seeds to low temperatures (near freezing) in the dark for 50 to 65 days before sowing. When so treated winter wheats sown in the field in the spring will behave as spring wheats. The principles of this method were reported from Ohio in 1858.

By chilling germinated seeds preparatory to planting at higher growing temperatures in a long day, it is possible for the experimenter to obtain two or more crops of winter wheat in a year, depending on the variety.

Seasonal growth habit in wheat is considered an aspect of earliness and lateness. So far as earliness is concerned the winter varieties have low-temperature and short-day optima during the initial growth phase, whereas spring varieties have optima at the higher temperatures and the longer photoperiods.

Earliness and lateness of sexual reproduction appear to depend on the interrelation of several characters, as the number of internodes per culm, the growth rate of the internodes, the duration of the elongation of the internodes, and environmental-response characters which influence the expression of these several characters.

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Endocrinology and Eugenics

ENDOCRINE MEDICINE *by* WILLIAM ENGELBACH, M.D., F.A.C.P., B.S., M.S., D.Sc., with a foreword by Lewellys F. Barker. Three volumes and an index volume. 1900 pages; 933 illustrations, $35.00. Charles C. Thomas, Springfield, Ill., and Baltimore, 1932.

THESE noteworthy volumes are frankly intended for the medical profession, and indeed for a new, rapidly advancing and difficult aspect of medicine. On this the main purpose of the work the present reviewer begs a silence which will accord with his incompetence. But an examination of these books indicates that, whatever their contribution to medicine may be, they also have an interest for the biologist, psychologist and anthropologist. This interest attaches particularly to the first volume, entitled General Considerations.

Each of the few previous attempts to master and summarize for others the anatomy and physiology of the endocrine organs has been gratefully received by a fast-growing group of endocrinologists. Because of the enormous number and variety of current yearly contributions to this subject it has been suspected that perhaps it is no longer possible for a single individual to accomplish a comprehensive summary of this field. To meet this difficulty, in the preparation of several chapters Dr. Engelbach has enlisted a certain amount of proof-reading and other aid from a number of specialists. The problem is further simplified in that the "endocrine triad represented by the suprarenal medulla, the pancreas and liver" is but little considered in the work, this having been reserved for a later volume. Again, sympathin and one or

two other hormones are of too recent record to permit their inclusion even in this newly published work.

The endocrinologist will profit by the factual surveys given in many chapters. Inevitably also he will find numerous omissions and minor errors. The experimental work of recent years on the hormones of the ovary and anterior pituitary is better and more fully presented than is that dealing with the other hormones. The hormones of the anterior pituitary are of course gradually coming into clinical use. The reviewer thinks that current work is proving that nearly all past and present anterior lobe preparations contain hitherto unsuspected admixtures of various effective principles, and that further animal experimentation should and will lead sooner or later to safer and purer preparations than are now available.

During several years Dr. Engelbach has conducted careful and important studies in anthropometry, convinced that "the basis for an endocrinic interpretation depends upon an established *normal* anatomic development." Chapter VII, Anthropometry, contains new data and considerations which should prove useful to anthropologists and students of growth. The author here states:

> The purport of this chapter is to define the normal yearly limitation of seven measurements, height, span, upper, lower, and circumference of the head, chest, and abdomen, and the weights in both sexes from birth to the age of twenty. These have been determined for each month during the second year, and at six-month intervals throughout the succeeding years to the adult age. With the exception of the circumference of the chest and abdomen, the measurements estimated do not normally change after completed epiphysical ossification at eighteen (female) and twenty (male). The normal variations of weight for each year from the age of twenty to sixty are appended. These estimations revise and supersede those given in previous publications.

The concluding chapter of Volume I points a significant contact of endocrine medicine with eugenics. We quote:

> Endocrinic interpretation affects certain tenets of eugenics which are, as yet, neither established nor universally accepted. . . . The moral right (to prevent propagation) as expounded by eugenic propaganda, necessitates thoughtful endocrinic observation before such principles can be advocated which deny the individual the right of reproduction. Absolute diagnosis of the severity and *incurability* of his defectiveness must be given the greatest consideration. For example, the psychiatric diagnosis of imbecility, idiocy, and moronism, is made upon the degree and not the cause of the individual's mental retardation. Some of these are due to endocrine deficiency which, if diagnosed and adequately treated at an early age, could be so altered as to result in an individual whose propagation might be desirable. . . . Without depreciating the value of the eugenic principles of prevention, the writer believes that recent developments in endocrinology should most certainly modify some of its advocated procedures. By treatment of remediable endocrinopathies and the interruption of the transmission of these defects the legal right of procreation might be conserved.

In this reference to "the interruption of the transmission of these defects" the reader will understand that the author is thinking of no change whatever in the gene or genes underlying such a defective characteristic—but of our present ability to supply the specific missing element of the (endocrine) environment and thus achieve the normal characteristic.

The fourth volume contains a bibliography in addition to an index of authors and an index of subjects.

OSCAR RIDDLE.
Cold Spring Harbor, N. Y.

ALLELOMORPHISM OF SILVER AND SIAMESE COAT VARIATIONS IN THE DOMESTIC CAT

CLYDE E. KEELER and VIRGINIA COBB
Howe Laboratory and the Boston Cat Club

COMPLETELY albinotic individuals have been found occasionally in many mammals including man. In all species which have been subjected to genetic analysis albinism behaves as a simple recessive Mendelizing unit-character. In the rabbit, guinea-pig and mouse there are two dilutions intermediate between normal intensity (Figure 2*A*) and albinism (Figure 3*D*) known in the rabbit as Chinchilla (Figure 2*B*) and Himalayan (Figure 3*C*). The Chinchilla coat is almost devoid of yellow pigment, but retains much of the black. The Himalayan has a white body, but pigmented nose, ears, feet and tail. The pigmented points are slightly diluted and the eyes are pink. When crossed to normal intensity Chinchilla and Himalayan, like true albinism, disappear in the hybrids as expected of simple Mendelian recessives. Chinchilla-Himalayan hybrids are, on the contrary, true Chinchillas instead of being of normal intensity, which fact proves the allelomorphic nature of their determining genes.

Superficially, silver of the cat (Figure 2*F*) resembles chinchilla of the rabbit (Figure 2*B*). Likewise, Siamese of the cat (Figure 3*H*) suggests Himalayan of the rabbit (Figure 3*C*) as was pointed out by Bateson.

We have no indisputable record of complete albinism in the cat, and if it exists at all, it may possibly be confused with dominant blue-eyed white. Yet these resemblances to the intermediate forms of rabbit, guinea-pig and mouse suggest that the albino series of allelomorphic genes may be represented in the cat both by silver and Siamese.

In attacking this problem it was first necessary to determine whether silver and Siamese of the cat are recessive unit-characters, as they are in other forms. The meager data recorded in the literature for Siamese crosses are confusing as has been shown by Bamber. That Siamese is a character recessive to normal intensity is suggested by our mating of a Black Persian male and a Siamese female. Three black male kittens were produced, one of which is shown in Figure 3*J*. Miss Doris Bryant has collected records of the progeny of Siamese females mated to alley cats (presumably of normal intensity). These show the production of 16 kittens all developing full intensity of pigmentation, which confirms the supposition that Siamese behaves recessively to normal intensity.

The results of controlled Persian matings under our own observation justify the conclusion that silver, also, is a recessive unit-character. Most of our matings were made using "smoke" (Figure 2*G*) which is merely due to the silver gene in combination with the non-tabby instead of the tabby gene.

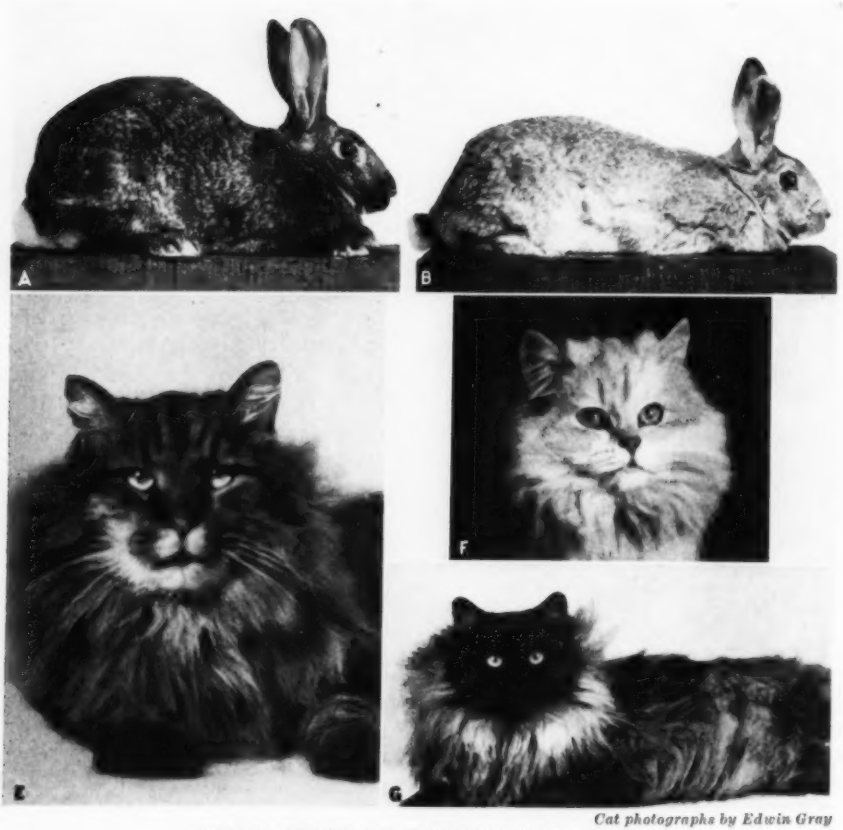
Gene symbols employed in our analysis are as follows:

T = tabby, t = non-tabby
C = full color, c^{cb} = silver, c^{H} = Siamese
L = short hair, l = Persian

Records for smoke matings are shown below:

Smoke Persian ($ttc^{cb}c^{cb}ll$) × Brown Tabby Persian ($TTCCll$) = 4 Brown tabby Persian ($TtCc^{cb}ll$)

Smoke Persian ($ttc^{cb}c^{cb}ll$) × Black Persian ($ttCCll$) = 5 Black Persian ($ttCc^{cb}ll$)



Cat photographs by Edwin Gray

COLOR-GENES OF RABBITS AND CATS

Figure 2

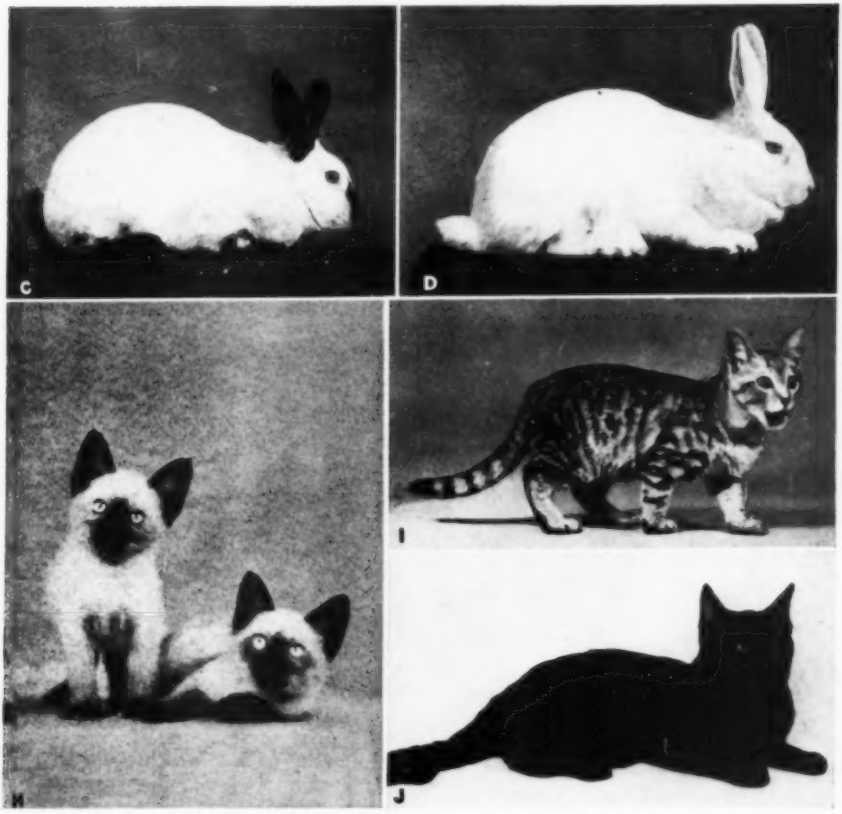
The albino series of alternative (allelomorphic) genes includes in the rabbit two intermediate dilutions between normal color (*A*) and albino (*D*); namely, chinchilla (*B*) and Himalayan (*C*). In the cat our evidence shows that silver (*F*) and Siamese (*H*) color patterns constitute a similar allelomorphic series. True albinism is not known in the cat. (*G*) is "smoke" cat, produced by combining silver and the non-tabby gene. (*I*) is a short haired silver tabby produced by mating silver tabby with Siamese and (*J*) is one of three offspring produced by mating a black Persian male cat and a Siamese female, showing the recessive nature of the Siamese pattern.

"Smoke" Matings (Continued)

Black Persian (hybrid for smoke) ($ttCc^{ch}ll$) × Black Persian ($ttCCll$) = 12 Black Persian ($ttCCll + ttCc^{ch}ll$)

Black Persian (hybrid for smoke) ($ttCc^{ch}ll$) × Black Persian (hybrid for smoke) ($ttCc^{ch}ll$) = 5 Black Persian ($ttCCll + ttCc^{ch}ll$) + 1 Smoke Persian ($ttc^{ch}c^{ch}ll$)

Black Persian (hybrid for smoke) ($ttCc^{ch}ll$) × Smoke Persian ($ttc^{ch}c^{ch}ll$) = 5 Black Persian ($ttCc^{ch}ll$) + 6 Smoke Persian ($ttc^{ch}c^{ch}ll$)



HIMALAYAN RABBITS AND SIAMESE CATS
Figure 3

See legend under Figure 2.

"Smoke" Matings (Continued)

Smoke Persian × Smoke Persian = 15 Smoke Persian
($ttc^{ch}c^{ch}ll$) ($ttc^{ch}c^{ch}ll$) ($ttc^{ch}c^{ch}ll$)

If Silver and Siamese are independent unit-characters, a cross between animals bearing them should produce offspring of normal intensity, but if allelomorphic the offspring should be silvers.

We crossed a Siamese female with a silver Persian male. There were produced three silver tabby short-hair kittens (Figure 3*I*) according to the formula:

Silver Persian × Siamese = 3 Silver tabby short-hair
($TTc^{ch}c^{ch}ll$) ($ttc^{H}c^{H}LL$) ($Ttc^{ch}c^{H}Ll$)

It was suggested to us by Prof. P. W. Whiting that in the above cross the silver gene (c^{ch}) might behave as a dominant in the presence of the tabby gene (T). Although we had observed a litter of hybrids bearing normal intensity (mentioned above) in which c^{ch} came into the cross from one parent and T from the other (Figure 2*E*) we decided to repeat the cross employing

non-tabby animals. Accordingly, we mated a Siamese female to a Smoke Persian male. Seven short-hair smoke kittens were produced:

$$\text{Smoke Persian } (ttc^{ch}c^{ch}ll) \times \text{Siamese } (ttc^{H}c^{H}LL) = 7 \text{ smoke short-hair } (ttc^{ch}c^{H}Ll)$$

At birth six showed very definite silvering on all parts of the body, whereas the seventh was darker than the rest and gave evidence of the silver factor only upon the appendanges and about the eyes.

Thus, it is evident that silver and Siamese of the domestic cat are due to alleiomorphic genes, corresponding respectively to the Chinchilla and Himalayan members of the albino series in other mammals.

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(Received for publication Oct. 21, 1932.)

China's Economics

CHINA TODAY: ECONOMIC, *by* J. B. CONDLIFFE. Pp. 188+ appendix of tabular data. World Peace Foundation, 40 Mount Vernon Street, Boston, 1932.

DR. CONDLIFFE'S several years' experience as Secretary of the Institute of Pacific Relations and his later contact with the League of Nations in preparing its *World Economic Survey* has given him an unusual opportunity for study of economic conditions in the Far East.

China Today is a review of economic conditions and possibilities of that great people whose present number is variously estimated to be from 325 millions to 474 millions, and whose future prosperity is surely related to that of the rest of the world. In the first two chapters the author critically reviews the contradictory evidence regarding population and agricultural resources and concludes that the population has almost reached its economic limit, thereby providing the basic foundation for most of China's problems of today, including war lords, poverty and bandits. Succeeding chapters deal with Agricultural Reorganization, Growth of Towns and Urban Industry, Public Finances, Banking and Currency Reform, and Foreign Trade. Sources of information, both old and new, have been thoroughly sought out and citations of references are abundant in the footnotes. The author's crystallization and interpretation of a great mass of evidence is admirably done. Eleven tables of tabulated matter, compiled from various sources, are included in a useful appendix.

This book should be very helpful in promoting, at this critical time, a better understanding among people of the Western World, of the problems of the China of today.

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Eugenics for Everybody

ERBBIOLOGISCHER UND EUGENISCHER WEGWEISER FUR JEDERMANN, *by* KONRAD DURRE. Pp. 95. Alfred Metzner Verlag, Berlin. 1932.

THIS "everyman's guide to heredity and eugenics" adopts an optimistic tone and supports it by reference to the spread of knowledge concerning eugenics in Germany since the war. It is of interest to find the author complaining that Protestant churches are lagging behind the Catholic in their interest in this subject. The book touches on a wide variety of topics, and is sensible in its comments.

PAUL POPENOE.

A LINEBREEDING PROGRAM FOR HORSE BREEDING

P. B. Pearson and Jay L. Lush
*Iowa State College**

BREEDERS have often made plans for linebreeding so as to keep a future herd closely related to a highly esteemed animal while avoiding all close breeding not necessary for that purpose. Rarely has such a plan actually been followed without material change for more than a generation or two. The writers recently studied the pedigrees of a stud of Belgian horses where such a definite plan has been followed without deviation for about fifteen years.

Mr. C. G. Good of Ogden, Iowa, has bred draft horses for many years, having bought his first purebreds in 1902. At first he bred Percherons then both Percherons and Belgians, but since 1914 he has bred only Belgians. About 1915 or soon afterward he became convinced that the Belgian stallion Farceur, 7332, had more desirable inheritance than any other animal in the breed. He reached this conclusion not alone because of Farceur's individuality (although Farceur had won some prizes in the show-ring, including the Grand Championship at the International at Chicago in 1913) but mainly because Farceur's sons and daughters had been winning in the show-ring more than the colts by any other stallion. He never went so far as to believe that Farceur was perfect, but he did think (and still does) that considering individuality and progeny together, Farceur was nearer the ideal than any other Belgian of his generation.

Mr. Good purchased Farceur in 1917 for $47,500, the record price in America for a draft horse. Immediately he embarked on a breeding plan originally evolved out of his youthful experiences in the breeding and showing of chickens.

This plan was to use Farceur as long as he lived, not, however, mating him to his own daughters. The two best sons of Farceur were to be saved for use on Farceur's daughters. One son of each of these stallions would be saved for use in the next generation but would be used on the daughters of the other stallion and not on his own half-sisters. Each of these stallions would in turn be followed by a son which would be used on the daughters of the other stallion. No animals would be added from outside the herd unless they already carried "50% of the blood" of Farceur. Thus the plan called for a stud ultimately closed to outside blood, with every animal in it containing 50% of the blood of Farceur but with inbreeding avoided as far as could be done in a closed population having only two sires in service at any one time. Mr. Good's aim was to keep all his horses for many generations into the future as nearly like Farceur as if they were sons and daughters. He recognized that in the initial mating of half-brother and sister (Farceur's two sons to Farceur's daughters) there was some risk of undesirable results. However he believed that, if the results of those matings were satisfactory, there would be practically no inbreeding risk in subsequent generations because there would be no more matings between half-brothers and sisters.

Figure 6 shows how the pedigree of the herd would appear for several generations under such a plan, omitting such complications as overlapping of generations, several offspring being saved out of some of the females, and unequal use of the two contemporary stallions.

The inbreeding first appears in the

*Journal Paper No. B62 of the Iowa Agricultural Experiment Station, Ames, Iowa.

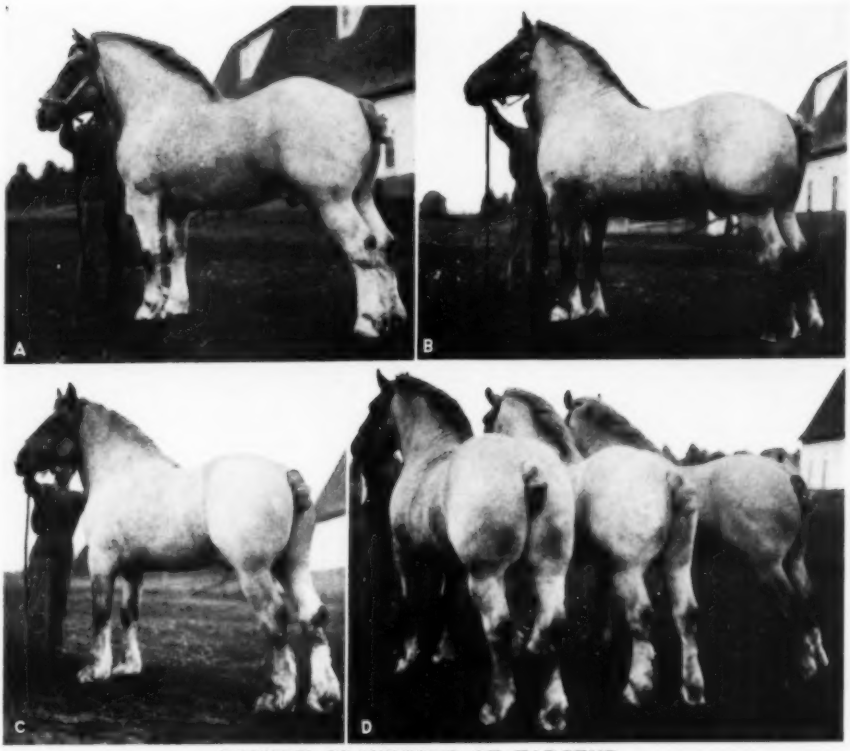
FARCEUR IN HIS PRIME

Figure 4

Rated by judges as a good individual and the sire of many prize-winning offspring. By an ingenious breeding system the attempt is being made to multiply his descendants without decreasing the proportion of his blood, even many generations in the future.

second generation (double grandsons and double granddaughters of Farceur) and then remains at that level for another generation. All the inbreeding in the second and third generations comes from Farceur himself and its danger depends not only on its intensity (12.5%) but also on whether Farceur had more or less than the usual proportion of undesirable genes which might thus be made homozygous. Since he and his progeny were highly esteemed, it is plausible to assume that he had fewer undesirable genes than the average Belgian horse of his generation. If this is the case there was at least a little less danger in the second and third generations of this plan than there would be in similar plans centering around horses which were only average individuals.

Beginning with the fourth generation there occurs some inbreeding to Oakdale Farceur and Farceur Supreme. With each succeeding generation there appears a little inbreeding to additional male descendants of Farceur. Since all these carry "50% of the blood" of Farceur, the genes made homozygous by this breeding system will be mostly genes carried by Farceur himself. However a little of the extra homozygosity appearing in the fourth generation (3.1% out of the total of 17.2%) will be for genes which originally came from the dams of Oakdale Farceur and Farceur Supreme. As the generations pass there will be more homozygosis of genes which originally came from the



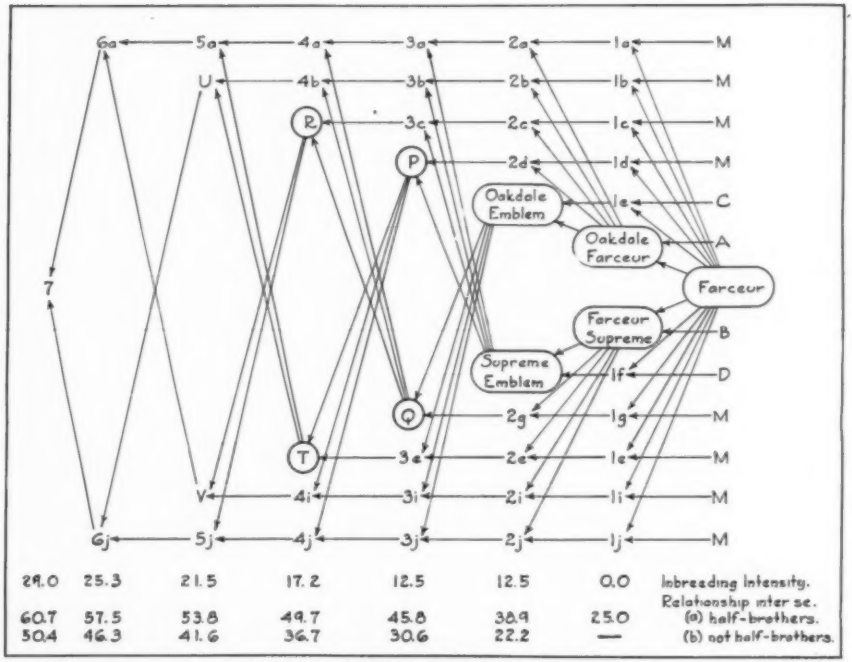
DOUBLE GRANDSONS OF FARCEUR

Figure 5

A—Supreme Emblem, born in 1926. A prize-winner in many shows, including a championship at the Ak-Sar-Ben show at Omaha. One of the first double grandsons of Farceur to be used in the stud. *B*—O'Resque, born in 1929. A leading prize-winner at many important shows of 1932, including a championship at the Ohio State Fair and Reserve Championship at the National Belgian Horse Show. A full brother to Marjorie and also to *I* whose pedigrees are shown in Figure 7. *C*—Radiant Farceur, first shown as a yearling in 1933. First prize at Iowa State Fair, sixth at National Belgian Horse Show. He is a full brother to *C* in Figure 7. *D*—Another view of the three double grandsons of Farceur. Their uniformity is apparent in spite of their difference in age.

foundation mares whose male descendants are saved for stallions. However, no matter how long the plan continues, there will always be more of Farceur's genes brought into homozygosis by the breeding system than there will be of the genes of all the foundation mares added together. Thus it seems legitimate to speak of this as linebreeding to Farceur, even though some of the homozygosis thus produced will be for genes from the foundation mares. After the third generation a little less than a sixteenth of the remaining heterozygosity is eliminated in each generation.

The relationship of the herd to Farceur (Wright's coefficient) will decline only slowly as the inbreeding increases. Except for the effects of selection and chance deviation, half of all the genes in the future herd will be from Farceur, as long as this breeding system is continued. The slight decrease in the rela-



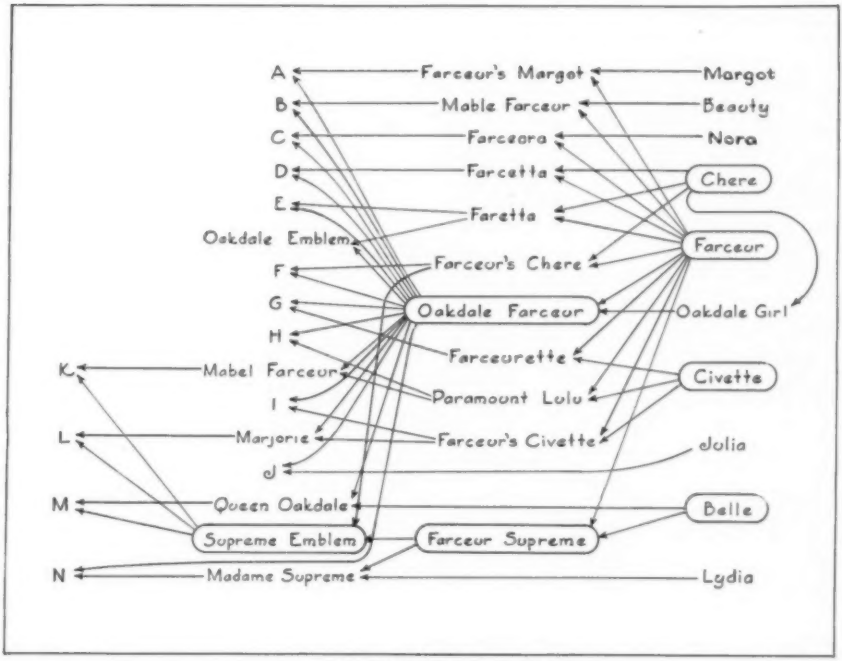
MR. GOOD'S BREEDING PLAN

Figure 6

Schematic outline of the breeding plan for perpetuating the influence of Farceur without close inbreeding. This simplified diagram omits such complications as overlapping of generations, one stallion being used more extensively than his contemporary, and the production of several colts out of some mares and none out of others. Eventually all the animals in the herd would be more closely related, and more alike than ordinary brothers and sisters.

tionship to Farceur as the generations pass merely reflects the increasing number of homozygous gene pairs in which both genes came from Farceur but were not homozygus in Farceur himself. With respect to these gene pairs the descendents are therefore not exactly like Farceur although receiving all their inheritance from him.

We said: "Except for the effects of selection. . . ." This is not intended to cast any doubt on the existence of such effects. But in organisms which multiply as slowly as horses do, selection by itself cannot be perfectly effective unless directed solely at a very few dominant genes (perhaps four or five would be the limit). When there are more genes involved, there are simply not enough offspring born to make it certain that the breeder can find any which contain all the desired genes even in the heterozygous condition. When some of the genes are recessive, or depend on the cooperation of other genes to produce any effects, or when the effects are obscured by environment, there will be many mistakes in selection. Trying to retain half of Farceur's genes among his descendants merely by selection, while breeding those descendants to unrelated animals, would be fighting against the laws of chance and the halving effect of Mendelian segregation—a struggle doomed to defeat in the end. A breeding system which by itself would tend to keep about 50% of the genes of Farceur in all the descendants



THE HERD OF TODAY

Figure 7

Colts foaled in 1932 are designated by letters. The foals of 1930 and 1931 are omitted. The actual herd differs from the "ideal herd" (Figure 6) in the overlapping of generations and in the unequal use of the two sires chosen to head the herd—Oakdale Farceur being preferred to Farceur Supreme.

would work in harmony with the laws of chance which operate in Mendelian segregation. If that were done selection could alter this proportion bit by bit, generation after generation, and whatever was gained in one generation would tend to be preserved in the next.

This is the essence of linebreeding—to stop the diluting effects of outcrossing so as to conserve the desired qualities of an esteemed ancestor but at the same time to keep the intensity of the inbreeding mild enough that the effects of random survival or elimination of the genes from the population will not get beyond the control of selection.

The degree of genetic uniformity of the population is one of the important consequences of any system of breeding. In this case all of the first generation are half brothers and sisters. In the second and later generations there are two groups. Those sired by the same sire are more closely related to each other than they are to their contemporaries sired by the other sire. This tendency for the stud to split into two families is held in check by the breeding plan which calls for crossing the two incipient families in producing the next generation. In the fourth generation the half brothers and sisters are about as nearly like each other as ordinary full brothers and sisters. In the seventh generation even those, which must go back to their grandsires to find common ancestors, are as nearly alike as ordinary full brothers and sisters. In the eighth and later generations the

whole herd would be distinctly more uniform than a group of full brothers and sisters. That would be a sight worth seeing!

Figure 7 shows the pedigrees of all the colts born in 1932 and indicates how far the breeding plan has actually progressed in the stud as it is today. Each foal is designated by a letter. Oakdale Emblem and Supreme Emblem are the stallions which will sire next year's colts.

The actual picture differs from the theoretical in several respects. In the first place the generations overlap. Secondly there is some linebreeding either already accomplished or almost certain to be accomplished in the near future to some of the mares, notably Chere and Civette. Thirdly there has been a marked preference for the use of Oakdale Farceur instead of Farceur Supreme wherever the mare to be bred was equally related to both of them.

The 1932 colts may be classified roughly as being in the second and third generations of the theoretical plan. The foundation mares lived so long that even among the 1932 colts there is one out of a mare with no Farceur blood and there are two out of dams which had only 25% of Farceur's blood. The inbreeding of the 1932 foals ranges from 0.0 to 18.8% but averages 12.8 as compared with an expected 12.5 for all colts of the second and third generations.

The relationship to Farceur averages 43.6 instead of the theoretical 47.1. The slight difference comes from the retention of some of the foundation mares after Farceur's death. This difference will grow less as long as the stallions used all carry 50% of the blood of Farceur.

The present relationships of certain ancestors to the 1932 colts and of those colts to each other are as follows:

Relationship of 1932 Foals

	Average	*Range*
To Farceur	43.6	25.0 to 47.1
To Oakdale Farceur	53.6	29.2 to 63.1
To Farceur Supreme	26.9	12.5 to 47.2
To Supreme Emblem	34.7	14.7 to 62.5
To each other	34.9	17.1 to 55.2
To Chere	18.3	6.4 to 34.4
To Civette	6.7	0.0 to 23.6

Both Oakdale Farceur and Farceur Supreme had been expected to be related 41.3% to the second and third generations under the theoretical plan. Oakdale Farceur died late in 1931. If all his daughters are mated to Supreme Emblem, Oakdale Farceur's average relationship to the herd of the future will diminish a little from that shown.

Several daughters each were saved from the mares Chere and Civette. Chere is the granddam of both stallions which sired the 1932 foals. Hence there is already some linebreeding to Chere and all future matings will involve a little more. She seems destined to stand second only to Farceur himself among the foundation animals in importance to the herd as long as this plan is followed. Her daughter, Oakdale Girl, and the mares Civette and Belle are also almost certain to be permanently important to the herd. One colt already is linebred to Belle. The other foundation mares, from which only daughters were saved, will soon lose their importance unless a male descendant is saved for use as a sire in this stud.

The greater importance of Oakdale Farceur than of Farceur Supreme indicates what will probably in the long run prove the biggest difficulty in the plan—selection of the best son to follow each stallion. Such selections must usually be made before the stallions are thoroughly progeny-tested and in some cases before they are even mature. If it were practical to run a three-stallion or, better still, a five-stallion herd, the risk of defeating the whole plan by making the same mistake in the selection of all the stallions used in any one generation would be negligible. On the other hand, a larger herd would slow down the rate of progress in fixing the desired traits and in building uniformity. Perhaps Mr. Good can be wise enough in his selections to keep control even with a two-sire plan. Certainly he has a better chance to do that

where he is selecting from among colts whose parents and grandparents were all owned by him, and even bred by him, than if he were to try to select a stallion from a herd he had rarely or never seen before.

Success of the System

Has the merit of the individuals in this herd remained the same, increased, or decreased as the breeding system has developed? There is no indisputable answer to this important question. Horsemen disagree about it. Perhaps the most purely objective answer is the fact that the firm of C. G. Good and Son has won the prize for premier *breeder* of Belgians at the Iowa State Fair ten times in the twelve years from 1921 to 1932, and at the National Belgian Horse Show at Waterloo, Iowa, ten or eleven times in the same twelve years. These awards are based upon the total amount of prize money won by horses bred by one man or firm. Good and Son's winning of this award is usually based upon their showing many young animals all of which do fairly well in their classes rather than upon winning very large prizes with one or a few extraordinarily outstanding individuals. At the same 24 fairs the banner for premier *exhibitor* of Belgian horses has been won by Good and Son 23 times. Certainly there is in this record no evidence of deterioration. Yet it should be remembered that this plan is only just coming into its third generation. Many of the winnings in the remarkable record just cited were made on animals of the first and second generations. The record may or may not continue to be as brilliant as this as future generations bred by this plan take their place in the show ring.

Horse breeding is a life-time program. Farceur was purchased in 1917 and died late in 1921. It is fifteen years since the plan was started and yet only two of the 1932 foals are purely in the third generation. How long will it be before the foals are all of the fourth generation? And how long until the seventh generation when they will all be more alike than ordinary brothers and sisters? How many of us will be alive to see them then, even if Mr. Good and his son do keep the stud together and maintain the original plan?

To geneticists this is an interesting case of the conserving effects of a linebreeding system balanced against the random elimination of genes. Such elimination of genes is an inherent consequence of any closed breeding system and is the basis of the well-known inbreeding effects. It may take place even in the face of selection for certain genes that are held to be desirable. The conserving effects of the breeding system and the elimination rate in the absence of selection can be calculated, but who knows how effective selection will actually be in modifying those rates? The rate of gene elimination in the absence of selection is almost inversely proportional to the number of stallions in use per generation. Probably it could be brought completely under the control even of faint selection if it were practical to keep four, five or even more stallions in service at all times. But this does not seem practical or profitable at present. Economics and farm management impinge on biological principles in the actual working out of such a plan.

Perhaps selection in the hands of a skilled horseman is effective enough to control the situation even in a two sire herd. At any rate there is no expense for purchasing other breeding stock while this plan is in progress. As nearly as we can estimate the magnitude of the forces involved, this plan seems to us worth the serious consideration of those breeders who, whether as a result of their own good judgment or almost purely by chance, have come into the possession of a sire which is distinctly above the average of its breed in merit.

SWISS BODY MEASUREMENTS

ABOUT fifteen years ago Julius Klaus of Switzerland died, leaving a fund to provide for publishing a series of original papers on heredity, social anthropology, and race hygiene, both in the form of monographs and in the form of popular articles as propaganda. In consequence there was founded the Archiv of the Julius Klaus Foundation for Heredity, Social Anthropology and Race Hygiene. It is located in Zürich. To date seven or eight volumes have appeared. The Foundation and the Archiv have been under the direction of Professor Otto Schlaginhaufen, many of whose anthropological studies have appeared in the Archiv.

Two of the latest publications have come to us. One by Ernest Biedermann deals with bodily form and function of sixteen-year-old students of apprentice-schools and canton-schools of Zürich. This is a quantitative study of 400 males, recording such things as stature, weight, chest girth, shoulder breadth, pelvic breadth and arm, thigh and calf girths. Also certain indices, or proportions, are computed, such as the relation of the upper and lower segments of the leg, the chest girth in relation to build, the breadth of the shoulders and pelvis to stature, relation between upper arm and thigh, and between pelvic and shoulder breadth. On the physiological side are included strength of pull and grip, of performance in calisthenics and field sports. Correlations are computed between the leg index and pull and grip, also between the square of chest girth and lung capacity. The individual measurements made on each of these students are printed, occupying twelve pages in small type.

There are some interesting results from this study. It appears that athletes have a better chest girth and broader shoulders, but not broader pelves than non-athletes; that they are stronger in running, jumping and suspension, but not quite so strong in pull and grip as the non-athletes.

The merchant apprentices show the weakest bodily development, the electricians and mechanics occupy a middle position, masons and locksmiths are the best developed of all. It appears that the group with the poorest physical development are more successful in running and jumping, while the heavy persons of the locksmith and mason groups have a good capacity for pulling and exercising pressure, but are poor in jumping and running.

Fibulae in Men and Monkeys

A second paper from Schlaginhaufen's laboratory and from the Archiv, is by Heinrich Sprecher, and has to do with the study of the form of the fibula in adult humans, in comparison with its development in other primates. This is a study of 161 pages, some 14 plates, and a bibliography of three pages, on the evolution, the individual development and the general form relations of the fibula.

The fibula, as everybody knows, is the smaller of the two bones of the lower leg. It might seem that so inconspicuous a bone could hardly justify a publication of 161 pages, but this amount of text is relatively small when compared with the extraordinarily large monograph which Carl Pearson devoted to the femur, or thigh bone.

It appears that in the earlier vertebrates the fibula was almost equally important with the other bone of the foreleg, the tibia. In the horse it has become a mere splinter, and in cattle there is only a trace of it. Sometimes it becomes fused to make one piece with the tibia, but that is in animals of rather limited locomotion. Finally, in man and the other primates the bone remains with an important function, but has become very much reduced, as compared with the other bone of the lower leg which carries

the main weight of the body to the foot.

An anthropometric study of the fibula requires an unbelievable amount of pains. There were six different instruments used for expressing quantitatively its variation in form, and there are no less than nineteen different dimensions measured, and some twenty-four proportional indices computed. These different dimensions and proportions are computed for some eighteen races of mankind including Australians, Negroes, South Sea Islanders, Chinese, Philippinos, Swiss, Indians, etc.

The results of the study are largely a comparison of the size and form of the fibula in the different groups. The author finds, after all this study, that the fibula shows indeed a great variety of forms, but little striking racial differentiation. Consequently, the fibula is of little importance in racial diagnosis. It does not, for example, compare for this purpose with the form of the nose or head, or even the proportion of legs to trunk.

CHARLES B. DAVENPORT

Order of Birth and Intelligence

ORDER OF BIRTH, PARENT-AGE AND INTELLIGENCE, *by* L. L. THURSTONE AND RICHARD L. JENKINS. 135 pages. The University of Chicago Press, 1931.

THE subject of this book is one on which much has been written but with few conclusions which have been generally accepted. In part this may be taken as meaning that average differences between earlier and later children or between the children of younger or older parents are at best not very great; but this conclusion is not wholly warranted. Some of the studies show rather striking average differences. The trouble is that the way of the interpreter of most of the statistics bearing on the matter is exceptionally full of pitfalls. Some of these are of the nature of that involved in the old riddle: Why do white sheep produce more wool than black ones? There are others into which even the most distinguished statisticians have fallen.

The authors of this book have had sufficient data to make possible an unusually direct attack on the problem. The Chicago Institute for Juvenile Research has on file more than 10,000 case records collected during a period of ten years of children varying from 1 to 21 years of age. Individual mental tests have been part of the routine. The first result which came out of a large random sample was a continuous drop in mean I. Q. from first to sixth child (76.9 to 69.5). Beyond this the numbers were inadequate. The correlation was $-.086 \pm .018$ which is clearly significant even though small. The authors point out that this relation may be due either to a real effect of order of birth, or merely to a negative correlation between social status and size of family.

To eliminate interpretations of the second sort, they then made a comparison of the records of families in which more than one child had been examined. They found that they had 382 cases in which both first and second born had been examined and comparison of all pairs of birth ranks from first to fifth born could be based on more than 40 families. These ten comparisons presented an opposite picture to that shown by the mass data. In all of them, the later child had the higher I. Q. Moreover in 13 out of 18 comparisons in which one or both of the children were later than fifth born, the later child had the higher I. Q. A least square determination of the increment of each birth rank, over the first gave the following results:

2nd	*3rd*	*4th*	*5th*	*6th*	*7th*	*last (of 8 or more)*
3.1	4.8	7.5	11.0	8.1	10.6	17.1

The authors conclude that mean I. Q. increases progressively with birth order at least as far as the 8th child but that age of parents is apparently not a factor by itself. They find that possible defects of standardization of the test for age is not a factor. They do not attempt to determine whether the effect is a prenatal biological one, or is due to increasing experience of the parents or to education of younger children by their older siblings.

This result in conjunction with the mass result referred to first implies a considerable negative correlation between size of sibship and I. Q. A detailed analysis shows that there is such a relation down to average I. Q. 65 ($r = -.188 \pm .018$) but that below this, mean size of sibship tends to decrease with decreasing I. Q. ($r = +.158 \pm .028$).

The data are brought to bear on several other questions of interest.

Part II contains a very useful review of the literature. The authors find no experimental studies in animals except one made by the reviewer. In a large inbred stock of guinea pigs the average percentage of white in the piebald pattern of the young increased with the age of the mother until the latter had reached her full growth. The percentage of polydactylous young fell during this period to a remarkable extent. These results show that prenatal biological effects are possible.

The authors list 166 papers bearing on the question in man, but find difficulties in interpretation prevalent. Among the best established relations to birth order are an excess of abnormal confinements, premature births and stillbirths in low birth ranks, also a light average weight at birth and heavy infant mortality. On the other hand there are fewer twin births and fewer Mongolian idiots than among later births. A rather imposing list of undesirable traits,—insanity, epilepsy, tuberculosis, criminality, mental defect and even albinism—have been alleged to be unduly numerous in the first born, offset to some extent by alleged longer duration of life after infancy, more genius and more likelihood of entry in *American Men of Science*, but these are all cases in which the difficulties of interpretation of the data, due to mode of collection, are great.

SEWALL WRIGHT
University of Chicago

Sex-Determination for the Layman

WILL IT BE A BOY? The Facts about Sex Determination, *by* FRIDTJOF OEKLAND. Pp. 116, price $1.50. The Century Co., 1932.

THE professional biologist is wont to scan with sceptical and jealous eye any work that purports to present in everyday English the mysteries of his field. He fully expects to find it littered with exaggerations if not actual inaccuracies. Expectations will come a cropper after a reading of Professor Oekland's little book of 116 small pages. Here the writer has managed to tell with up-to-dateness and scientific exactness, with excellent pedagogy and in an engaging style the basic facts of our present day knowledge of sex determination. While the chromosome basis of sex is naturally stressed the physiological theories are not neglected. I found myself wishing at times that the discussion of certain phases of the subject (particularly the physiological) was a bit more extensive; but as it is, it is adequate for the reader for whom it was intended and indeed as collateral reading for the average undergraduate. The publishers might take unfair advertising advantage if they so desired of the title of the last chapter "How to produce the sex desired" which, of course, of present necessity can hardly live up to its suggestiveness.

ROBERT T. HANCE
University of Pittsburgh

DETERMINING SIMILARITY OF TRIPLETS AND QUADRUPLETS

A Quantitative Expression Derived from Measurements of External Body Dimensions

S. E. Torsten Lund
University of Minnesota

RECENTLY the writer completed a rather intensive psycho-biological study of a set of nine-year old girl triplets. In making the analysis of the resulting data, considerable difficulty was experienced in arriving at some quantitative expression of degree of similarity of the triplets with respect to body build. The usual method of inspecting the results of the measurements and arriving at a subjective judgment gives results which are of unknown validity and reliability. In addition, such results are not comparable to those obtained by other investigators, which, after all is a criterion of paramount importance. Faced with this dilemma a paper by Aebly[1] was discovered which illustrated one method. Later it was learned that Verschuer[7] and Dahlberg[3] have also worked out methods for expressing the degree of similarity of twins with respect to their external body dimensions. The writer has devised an extension of this method which can be applied to the analysis of triplet and quadruplet data.

Aebly describes four measures of similarity, only one of which will be reviewed in detail. Let x_1, x_2, x_3 . . . . x_n represent the measurements of the various body dimensions of twin *A*, and x'_1, x'_2, x'_3 . . . . x'_n the corresponding measurement on twin *B*. Then one measure of degree of similarity can be calculated by means of the following formula:

$$\sqrt{\frac{(x_1-x'_1)^2+(x_2-x'_2)^2+\ldots(x_n-x'_n)^2}{n}}$$

An alternate method suggested is that of finding the mean of the differences without squaring and extracting the square root. It will be noted that either of these methods has but limited usefulness, as it can only be used when the measurements are all in the same units, and are not too widely different in magnitude.

The method used by Verschuer is applied as follows:

Let *m* represent a measurement of one body dimension on twin *A*, and *m'* the corresponding dimension on co-twin *B*, then

(1) $\dfrac{m+m'}{2}$ = Mean of Measurement (*M*)

(2) and $M - m$ (or m') = The deviation of either measurement from *M*.

(3) Dividing (2) by (1) results in converting the deviation into a relative value, the per cent of the mean value of the two measurements (P.D.). The above calculation is then made for each body dimension measured. The resulting P.D.'s, are thrown into a distribution, the median per cent deviation and some measure of variability calculated. In this manner we arrive at one single quantitative expression of the degree of similarity of a set of twins. In order to give greater weight to extreme differences in the measurements, the writer suggests that each P.D. be squared, the $(\text{P.D.'s})^2$ be summed, the mean $(\text{P.D.})^2$ calculated and the square root extracted. The method used by Dahlberg is very similar to that of Verschuer, the main difference being that the total difference in each measurement is converted into a per cent of the mean of the two measurements.

In order to make use of either of the above methods in the study of triplets and quadruplets, it is necessary to modify the above procedure somewhat. This modification consists of breaking up the data for a set of triplets into three different sets of comparisons, while in the case of quadruplets, six different comparisons must be made. In order to illustrate the method, the analysis of the anthropometric measurements on the Keys quadruplets as reported by Spier[6] and Brintle[2] is presented in Table I. For our purpose we designate the quadruplets as follows: Roberta (*W*), Mona (*X*), Mary (*Y*), and Leota (*Z*). The per cent deviation (P.D.) has been calculated for each of twenty body dimensions according to the following six comparisons: *W-X*, *W-Y*, *W-Z*, *X-Y*, *X-Z*, and *Y-Z*. The resulting table of P.D. values is too lengthy to reproduce here, the median values, together with those of the upper and lower quartiles only being given. In addition, the median value resulting when the P.D. values were squared, the median $(P.D.)^2$ calculated, and the square root of the latter extracted is set forth in the table as Median B.

The above results are particularly interesting in the light of Spier's tentative conclusions: "Roberta (I) and Mona (II) are as nearly identical as identical twins usually are, Mary (III) hardly less different, while Leota (IV) is as different as siblings are ordinarily."[6]

The results of the above analysis do not bear out these conclusions, for according to the per cent deviations, *X* and *Y* (Mona and Mary) are most nearly alike in their body dimensions as sampled by twenty measurements, although *W* and *X* (Roberta and Mona), and *W-Y* (Roberta and Mary) show but slightly greater degree of dissimilarity. The above finding is borne out by the alternate method represented by Median *B*. To be sure, Spier's conclusions should not be questioned on the basis of anthropometric measurements alone, as they were undoubtedly arrived at by including the subjective appraisal of facial similarity, hair and eye color, etc.

In Table II, the summary of the analysis of the external dimensions of three sets of presumably one-egg triplets is given. Note that in case *W* there is a marked intra-triplet difference in the case of the *Y-Z* comparisons, while such difference in case *J* and case *E* is less marked. Interestingly enough, there is an indication that triplets resemble each other to a some-

TABLE I. Summary of Percent Deviations in Twenty Body Dimensions—The Keys Quadruplets.*

	W-X	W-Y	W-Z	X-Y	X-Z	Y-Z
Q_3	1.75%	2.12%	2.75%	1.88%	4.00%	3.25%
Median	1.33	1.33	2.00	1.20	3.33	2.00
Q_1	.88	.50	.50	.41	2.00	1.50
Median B	1.85	1.94	2.30	1.70	3.49	3.08

* Calculated from the data reported by Spier.

TABLE II. Summary of Similarity in Body Dimensions of Three Sets of Triplets.

Case		X-Y	X-Z	Y-Z
J[4] 93 dimensions ♀ Age 9 yrs.	Q_3	2.10%	2.54%	2.54%
	Md.	1.09	1.12	1.31
	Q_1	0.41	0.53	0.50
W[5] 20 dimensions ♀ Age 4½ yrs.	Q_3	2.0 %	1.75%	1.30%
	Md.	1.10	1.05	0.57
	Q_1	0.60	0.45	0.35
E[5] 20 dimensions ♀ Age 8 yrs.	Q_3	1.45%	1.62%	1.40%
	Md.	1.00	1.15	0.95
	Q_1	0.45	0.65	0.35

what greater degree than do quadruplets, and Verschuer's data[7] indicate that identical twins show a greater degree of similiarity than either triplets or quadruplets, insofar as we have available quantitative data for making such comparisons.

The advantage of using this measure of similarity lies in the fact that, not only does it make possible the expression of similarity in a quantitative manner, but also makes the results comparable with similar data derived from the study of siblings and twins. Strictly speaking, for use in triplet and quadruplet study, the method consists in analyzing the data as if they were concerned with three sets of twins (triplets) or six sets of twins (quadruplets). In the case of triplets, a measure of similarity could be arrived at by using the mean of the three measurements of each body dimension as the base, but such procedure would destroy the comparability of the data with results obtained from the study of twins, and could, of course, not be applied in the case of two egg triplets, especially where one of the triplets was of different sex. Although the above method does entail considerable work, and its reliability is limited by the reliability of the measurements made, the application of this method of analysis to the measurements of body dimensions of siblings, twins, triplets, quadruplets, etc., would eventually make it possible to collect norms which would be very valuable in the study of the relative effect of heredity and environment in influencing somatic development.

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Livestock Ecology

GRUNDLAGEN, WEGE UND ZIELE DER OKOLOGISCHEN HAUSTIER-GEOGRAPHIE, *by* Stefan Taussig. (Reprint from *Zeitschrift für Züchtung.* Reihe B, XXV, 1932). Pp. 121; 11 figures, 3 colored maps. Berlin: Paul Parey, 1932.

On the assumption that morphological and physiological traits of animals are predominantly determined by the environment, the author proposes, in rather lengthy outline, a procedure for investigating the ecological factors involved in the geographical distribution of domestic animals. This includes first, a classification of various environmental factors, including those due to domestication itself, as well as natural conditions of climate, soil, vegetation, etc.; and second, a tabulation of the characteristics of the animals (breed type, color pattern, etc.; physiological, and even psychological, traits) which are to be studied in this connection.

Taussig appears to give no attention to matters of fad and fashion, which are not infrequent factors in determining the popularity of a breed or type in a particular region, nor does he seem to recognize that the breeding methods employed in a given locality may in many instances have more to do with the productivity of the animals

than do climatic and other similar factors.

It will hardly be questioned that it is desirable to know the optimum environmental and nutritive conditions for domestic animals, which is one of the objectives the author hopes to achieve, but the use of his methods for ascertaining these facts seems rather cumbersome. The work includes several rather interesting maps illustrating the distribution of cattle breeds in Germany, Switzerland, and Holland, and a number of diagrams reprinted from other authors to demonstrate methods of presenting ecological data. The bibliography is of astonishing catholicity, though many of the titles in it appear to have little relevance to the text.

PAUL R. DAVID
Storrs Agricultural Experiment Station.

Poultry Genetics Up to Date

POULTRY BREEDING, *by* MORLEY A. JULL. pp. XIV + 376. John Wiley & Sons, Inc., New York, 1932.

THROUGH the rapid growth of the poultry industry and the increasing use of poultry as material for biological investigation, the domestic fowl has now become the most numerous and the most thoroughly known of all of our domesticated animals. For the large and varied audience of farmers, poultrymen, students in agricultural colleges, teachers, investigators and others interested in poultry, Dr. Jull has prepared a summary of the written record of knowledge concerning poultry breeding. In making selections from the voluminous literature he has recognized the prime fact that the practice of breeding animals depends upon the operation of general biological principles and most immediately upon those which deal with heredity. Two-thirds of his book, therefore, are devoted to a review of the inheritance of the various characters of the fowl which have been studied: color, form, structure and size, physiological traits, egg laying, characters of the egg, etc. This is preceded by a general description of the mechanism of reproduction and heredity and is followed by a discussion of breeding practices, methods for improving the economic qualities of the fowl and practical directions for trapnesting, pedigreeing and record-keeping. Extensive bibliographies and a good index increase the usefulness of the book for reference purposes, and the inclusion of photographs, charts and tabular material should make it palatable for students and general readers.

The summary of the literature which is the chief feature of the book represents an improvement over previous treatments in respect to completeness, although evaluation of results and critical comment are often replaced by quotation of data, which may be welcomed by the advanced student but may sometimes confuse the beginner. Anyone, however, should be able to find in the book adequate introduction to the sources of information on the important features of inheritance and reproduction in the fowl.

As a text book also it is a welcome departure from those usually available for courses in animal breeding for it confines itself to facts and principles and leaves to the teacher and to individual experience the inculcation of the "art of breeding," which frequently seems to consist merely of the combined judgments of successful breeders presented as short-cuts or formulæ for immediate application. The use of a book of this sort should raise the standard of instruction in agricultural courses which so often teach practice rather than principle.

L. C. DUNN
Columbia University.

INBREEDING BERKSHIRE SWINE

E. H. HUGHES
California Experiment Station

THE term inbreeding may be applied to breeding operations which involve the mating of relatives and which lead to a uniform type of animal. The degree of inbreeding depends upon the relationship of the mated animals. There seems to be conflicting evidence on the value and results of inbreeding. Miss King at the Wistar Institute, where rats were used as the experimental animal, showed that inbreeding accompanied by careful selection did not produce adverse results. Wright,[1] working with guinea pigs, found that the average effect of continued inbreeding was to cause a decline in all elements of vigor.

Cole[2] states, "The success or failure of inbreeding lies in the individuals selected—such results are the effect of recombinations of the germ plasm and necessary selection of a few individuals to breed from. The inherent difficulty is in obtaining the proper combination of heritable qualities and of recognizing it when it appears."

Inbreeding of Swine

In an effort to improve the types of cattle in England, Bakewell, Bates and others mated closely related individuals. Careful selection for desirable characteristics, as they knew them, was rigidly practiced. This practice resulted in a manifestation of marked improvement in the types they were attempting to produce. Gentry, a master breeder and judge, successfully followed, in fact is still following, the same principles in the production of a superior type of Berkshire hog. These men were eminently successful in establishing certain superior qualities in the animals they were breeding. No doubt the rigid selection and mating of superior individuals was one of the important reasons for their successes.

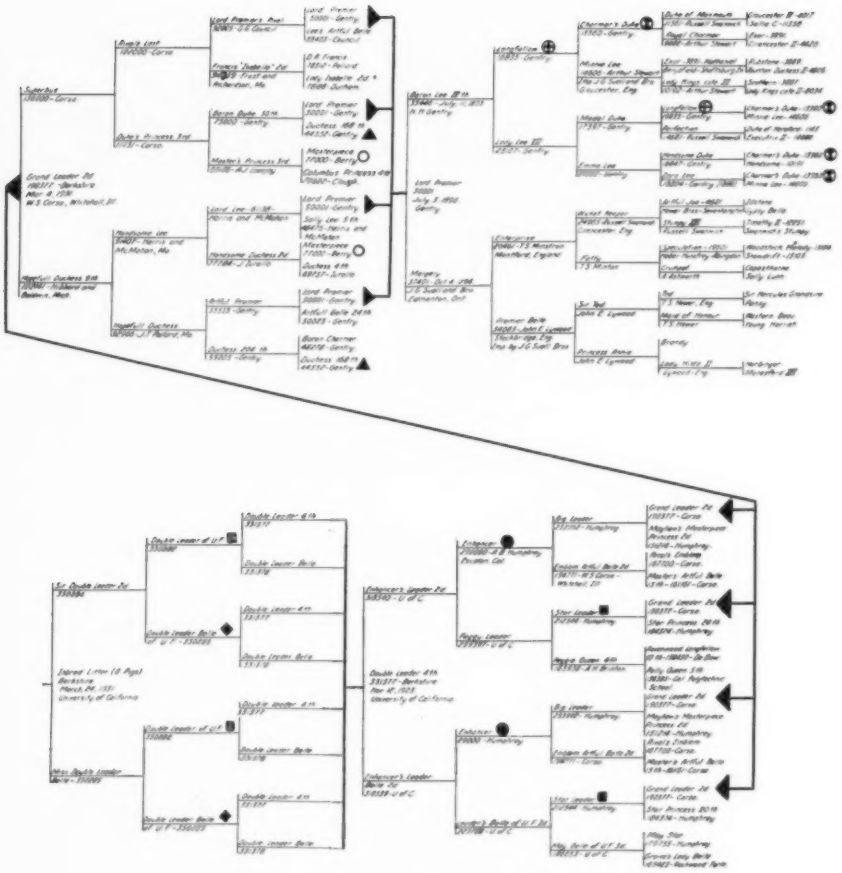
Hayward[3] reports the double mating of inbred Berkshire sows with an inbred Berkshire boar and a purebred Chester White boar. In a number of litters pigs sired by each boar were farrowed. The white pigs in these litters were a check on the black inbred litter mates. The crossbred pigs showed superior size, growth and vigor over the purebred, inbred, Berkshires in the same litters.

Inbreeding experiments with swine at four places in the United States, covering a considerable period of time, has been discussed by McPhee, Russell and Zeller[4,5]. An inbreeding experiment with Poland Chinas has been in progress at the University of Minnesota since 1923-24. Duroc Jerseys have been inbred at the Oklahoma Agricultural College for a number of years. At Clemson Agricultural College Berkshires have been inbred. Chester Whites, Tamworths and Poland Chinas have been inbred at the United States Department of Agriculture Experiment Farm at Beltsville since 1923-24.

As a result of inbreeding at each of the four places there has been an indication of a loss of vigor in the inbred pigs. At two of these stations some difficulty has been experienced in getting inbred boars to mate with litter mate sisters. The segregation of a different color from breed standards has occurred with the Poland Chinas at the University of Minnesota and at the United States Department of Agriculture Experiment Farm. The appearance of structural abnormalities among the inbred strain has been rare.

Inbreeding Berkshires

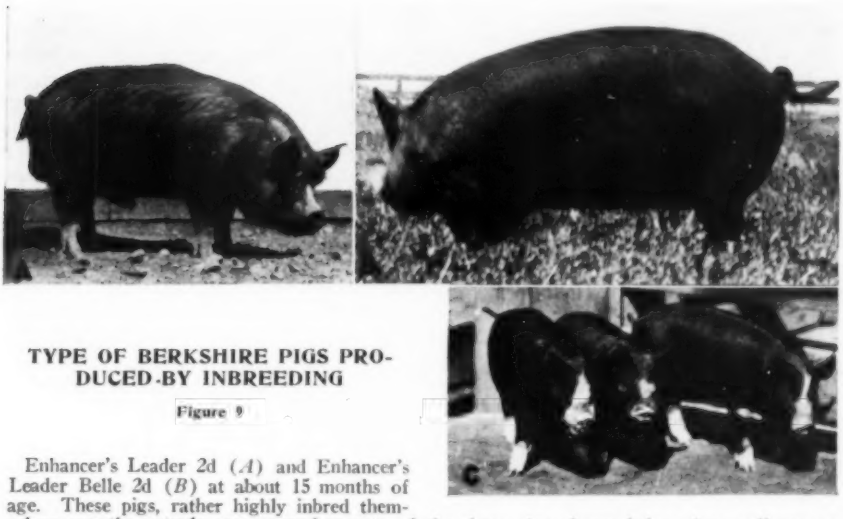
Desiring to add further knowledge to this important subject, an experiment was begun at the University of



PEDIGREE OF INBRED PIGS

Figure 8

Extended pedigree of inbred litter of Berkshire pigs born March 24, 1931. It will be seen from this pedigree that the pigs are very highly inbred. The coefficient of inbreeding (Wright) of these pigs is 74.00, which compares with a coefficient of 66.00 for one of the Bates shorthorn cattle, and of 25.00 for the inbreeding resulting from the mating of brother and sister whose father and mother are not inbred. It will be seen that for the first four generations there are only two individuals in each generation, and in the first seven generations there are only 25 ancestors instead of 254, as would be the case were no inbreeding involved. The experiment has been complicated by infection with abortion disease, but even with this adverse factor the very intense inbreeding practiced has produced no strikingly adverse results.



TYPE OF BERKSHIRE PIGS PRODUCED BY INBREEDING

Figure 9

Enhancer's Leader 2d (*A*) and Enhancer's Leader Belle 2d (*B*) at about 15 months of age. These pigs, rather highly inbred themselves, are the octuple great grand-parents of the three pigs shown below (see pedigree on opposite page). The three pigs (*C*) are the survivors at 47 days of age of a litter of 8 pigs born March 24, 1931 (one was lost the day before the photograph was taken). Although they are the product of three generations of brother-sister mating these pigs show no gross abnormalities nor defects.

California in 1922. At that time there were in the University herd several Berkshires that were very closely related. Two of these animals were Enhancer's Leader 2d and Enhancer's Leader Belle 2d. They were both sired by Enhancer and out of sows sired by the same boar; namely, Star Leader. Star Leader and Big Leader the sire of Enhancer were both sons of Grand Leader 2d.

Enhancer's Leader 2nd was mated to Enhancer's Leader Belle 2d. This mating resulted in a litter of ten farrowed and nine raised. A boar, Double Leader 4th, and a litter mate Duble Leader Belle, were saved and mated. They were selected because they were the largest, and most vigorous pigs in the litter. From this mating a boar Double Leader of U. F. and a litter mate Double Leader Belle of U. F. were saved and mated. As a result of this mating Sir Double Leader and his litter sisters, Miss Double Leader Belle and Miss Double Leader Belle 2nd were selected and mated. From these matings two litters were farrowed in the spring of 1931.

Record of Pigs Farrowed

The record of production for Peggy Leader, the dam of Enhancer's Leader 2d.

1917	1 Litter	10 pgs	Average 9.17 pigs per litter
1918	1 Litter	12 pigs	
1919	1 Litter	9 pigs	
1920	Spring Litter	9 pigs	
	Fall Litter	9 pigs	
1922	1 Litter	6 pigs	

The same for Leader's Belle of U. F. 3d the dam of Enhancer's Leader Belle and Enhancer's Leader Belle 2d.

1917	1 Litter	10 pigs	Average 9.33 pigs per litter
1919	1 Litter	11 pigs	
1920	Spring Litter	9 pigs	
	Fall Litter	6 pigs	
1921	1 Litter	13 pigs	
1922	1 Litter	7 pigs	

Enhancer's Leader Belle 2d mated to Enhancer's Leader 2d, litters farrowed in 1923-24-25. Litters farrowed in 1926 sired by a boar of another breed.

1923	1 Litter	10 pigs	Average 11.0 pigs per litter
1924	1 Litter	11 pigs	
1925	1 Litter	15 pigs	
1926	Spring (cross breds)	11 pigs	
	Fall (cross breds)	8 pigs	

Enhancer's Leader Belle mated to Enhancer's Leader 2d.

1923	1 Litter	10 pigs	Average 10.2 pigs per litter
1924	Spring litter	10 pigs	
	Fall litter	9 pigs	
1925	1 Litter	13 pigs	

Double Leader Belle mated to Double Leader 4th (litter mates).

1926	1 Litter	9 pigs	Average 10.0 pigs per litter
1927	1 Litter	10 pigs	
1928	1 Litter	11 pigs	

Double Leader Belle of U. F. mated to Double Leader of U. F. (litter mates) litters farrowed in 1928-29. The 1930 litter was a cross bred litter and the 1931 litter was sired by a son, Sir Double Leader.

1928	1 Litter	7 pigs	Average 8.75 pigs per litter
1929	1 Litter	8 pigs	
1930	1 Litter (cross breds)	11 pigs	
1931	1 Litter	9 pigs	

Miss Double Leader Belle and Miss Double Leader Belle 2d, mated to Sir Double Leader Belle (all litter mates).

1931	Spring litter	8 pigs	Average 7.0 pigs per litter
	Spring litter	6 pigs	

During the years from 1919 to 1926 inclusive Berkshire Sows in the University herd, have averaged 8.14 pigs farrowed per litter. This is from a total of 71 litters farrowed by sows of all ages. They were sired by 11 different boars. Since 1922 there has been a total of 18 litters farrowed by inbred sows, except for four litters, all have been sired by litter mates. The average size of these litters was 9.78 pigs, 1.64 pigs more to the litter than the average for all Berkshire sows during the years 1919-1926 inclusive. While the average size of inbred litters is greater than for the average of our Berkshire herd, the litters from Miss Double Leader Belle and her litter sister Miss Double Leader Belle 2d were not so large as the average of the litters farrowed by Enhancer's Leader Belle and Enhancer's Leader Belle 2d, two of the first sows used in this study. The litters from Miss Double Leader Belle and her litter sister, however, are first litters, and it has been shown* that first litters are smaller than later ones, there being an average difference of 2 pigs per litter between the first and fourth litters.

Abortion Disease a Factor

Early in 1929 nearly half of the hogs in the college herd reacted to the agglutination test for swine abortion. Prior to this date breeding difficulties had been encountered. Sows would farrow normally in the spring and fail to conceive for a fall litter. There was no definite means of knowing how long some of the inbred animals had been infected with the abortion organism. During the early part of the calendar year 1931, all the inbred Berkshires on this experiment reacted to the abortion test.

From the 1931 spring crop of inbred pigs, three pigs, one boar and two gilts have been saved that are free from abortion. These young inbred animals will form a nucleus for the continuation of the experiment free from at least one serious influence that probably affected the birth weight of the young pigs and which was probably partially responsible for some of the breeding difficulties experienced during the past years.

Because of the foregoing facts no birth or weaning weights are reported in this paper. The number of pigs farrowed per litter seemed a more accurate measure of our inbreeding results.

Extended pedigrees of an inbred litter farrowed in March, 1931, of Double Leader 4th. of Grand Leader 2d, and of Lord Premier, are presented (Figure 8). An examination of this pedigree of the inbred litter farrowed in March, 1931, presents a record of the inbreeding operations since 1922. The pedigree of Double Leader 4th reveals the fact that his

* Records of 1,152 litters and 10,555 pigs from breeding records of 10 experiment stations and college herds (South Dakota, Wisconsin, Michigan, Illinois, Cornell, Nebraska, Missouri, Kansas, Purdue and Ohio).

sire (Enhancer's Leader 2d) and his dam (Enhancer's Leader Belle 2d) were very closely related. Grand Leader 2d was an inbred boar himself, Lord Premier appearing four times in the fourth generation. Finally an examination of the extended pedigree of Lord Premier shows that he was somewhat inbred himself, particularly on his sire's side. Longfellow 16835 appears twice in the first four generations and Charmer's Duke 13360 appears four times in the first five generations. All the animals on the mother's side of the pedigree of this boar were bred in England except his dam. She was bred in Canada.

Photographs of Enhancer's Leader 2d, Enhancer's Leader Belle 2d and of three of the inbred 1931 spring litter are presented in Figure 9, to illustrate the type of Berkshires that are and have been used in this study.

Summary

1. The average number of pigs farrowed, in the inbred litters, have been greater (9.78 pigs per litter) than the average for the Berkshire herd (8.14 pigs per litter for the years 1919-1926 inclusive).

2. There has been a slight but gradual decrease in the number of pigs farrowed in the inbred litters since 1923. The last litters, however, were the first litters of the sows in question, which tended to be smaller.

3. The type of the pigs in all the inbred litters have been similar.

4. There has been no noticeable color change or structural abnormalities in any of the inbred pigs.

5. The results obtained thus far seem to agree in part with those of Miss King (no noticeable loss in size or vigor) and in part with the results of other workers (there has been a slight decrease in size of the inbred litters).

6. The standard deviation from the mean of the inbred litters is 2.56 with a probable error of ± .288. The standard deviation from the mean of all Berkshire litters from 1919 to 1926 inclusive is 5.34 with a probable error of ± .302.

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The Disintegration of a Primitive Culture

THE CHANGING CULTURE OF AN INDIAN TRIBE, *by* Margaret Mead. Pp. xiv+313, price $4.50. Columbia University Press, 1932.

THE relationships between primitive and advanced peoples constitute one of the major problems of modern civilization, especially any civilization,—if there be one— which looks far into the future. Such problems have existed for ages, but have generally been left to solve themselves, the contacts beginning with invasion and in modern centuries going on in the hands of missionaries and traders until, with increasing numbers of the white invaders, problems of administration and government obtruded themselves. Only relatively recently has the more enlightened study of the effects of such racial contacts from the anthropological, sociological and psychological points of view begun to suggest how much con-

tacts should take place and how they might be controlled.

Dr. Margaret Mead has made a study of the present condition of a tribe of Plains Indians in the buffalo country west of the Mississippi. She sketches briefly the earlier history of the tribe since contact with the white man began about the middle of the seventeenth century. The identity of the tribe is disguised under the name Antlers, the names of individuals are also altered throughout and sometimes suppression of other information is considered necessary, in order to avoid disclosing the particular reservation where the data were collected.

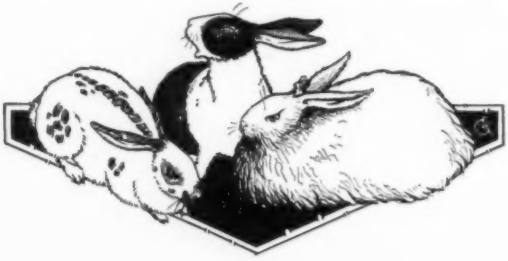
The tribe originally built earth lodges (some of large size), hunted buffalo, cultivated maize, held potlatches and had a complicated system of kinships and taboos. By the middle of the nineteenth century their reservation was demarcated and they were nominally Presbyterians. Their present condition, as it has developed since 1900, is detailed in this book, and shows how misguided Government administration has resulted in the disintegration of their own primitive culture and its replacement by utterly chaotic social and economic conditions, rapidly changing in each generation with increasing dissatisfaction of both Indians and whites.

No particular blame can be attached to the American government for this state of affairs. Successive generations of officials no doubt acted in what they considered the most enlightened way to produce rapid absorption of white civilization by a primitive people. But their policy was determined at a time before the problems relating to the psychology and development of primitive peoples and their reactions to white influence had even been defined. The Indians received the franchise, on the generous supposition that this would be an aid in absorbing an alien European culture much of which was beyond their comprehension. At the same time they were made land owners, each family receiving a parcel of at least 40 acres, although the whole conception of individual land ownership was entirely foreign to their tribal organization. The leasing and sale of their property has led to the eruption of white people into the community, with its many disintegrating secondary effects.

Although it is now impossible to return to earlier conditions, yet many improvements could doubtless be made, for instance by altering the present system of education, which unfits so many of the Indians for later life and uproots the foundations of their original morality. As a study in maladjustment and its results, this book should be useful in indicating directions in which the administration of Indian reservations could be altered for the benefit of all concerned, although the authoress is at pains to make her work a purely scientific investigation of conditions as they now exist.

R. Ruggles Gates

University of London



LIVING AND NON-LIVING

THE MECHANISTIC AUTONOMY OF NATURE, *by* CARL F. KRAFFT. 101 pages, price $1.00. Published by the author. Washington, D. C., 1932.

TWO entirely different lines of attack are open for investigation of the nature of life processes. One line may be described as inductive; it is based upon the assumption that life processes are not so totally different from processes in inorganic systems but that certain points of similarity can be found. The investigations then begin with a search for such points of similarity and lead on through chemical and physical studies to elucidate their nature and to determine to what extent a comparison of certain processes in non-living systems to certain life processes is justified. A highly abbreviated review of such work is given in a volume recently published by the reviewer (R. BEUTNER. Physical Chemistry of Living Tissues and Life Processes, Baltimore, 1933).

The other line of attack denies *a priori* that the essential features of life can be compared to anything in the non-living world and begins with speculations as to the nature of the irreproduceable vital processes. Such speculations are probably as old as mankind itself. Whereas formerly they were draped with a variety of religious, or philosophical considerations, it is now-a-days more common to adapt them to modern scientific conceptions.

Krafft's book sets forth new hypotheses of this character. It is to be hoped that some of his ideas may prove useful and stimulating for future scientific development, but it is difficult to see just which new points of attack he suggests. After an introductory chapter in which all irrational view points are condemned, the writer gives his ideas on atomic structures attempting to reconcile the old "vortex theory" with the modern conception of electrons, protons, etc., as building stones of the atoms. He then passes to the discussion of biological problems. He emphasizes particularly the complete difference between the living and the non-living nature, and furthermore states that "the ultimate cause of life must be the same for all living organisms because living matter is always composed of substantially the same protoplasmic material and always passes through the same cycles of growth and reproduction regardless of its rank in the plant or animal kingdom."

The vague terms "living material" and "protoplasm," have led here, and elsewhere, to considerable confusion. According to such a prominent biochemist as Gowland Hopkins: "There is no such thing as living matter in a specific sense. The special attribute of such systems from a chemical standpoint is that these reactions are organized, not that the molecules concerned are fundamentally different in kind from those the chemists meet elsewhere." (GOWLAND HOPKINS, *Lancet*, 1925).

Why "living matter" should always be essentially identical is hard to understand. Does it not appear to exist in endless varieties of quite different character?

The writer then reviews what he calls "protoplasmic chemistry" this being essentially the well known chemistry of proteins. (Lipoids and carbohydrates are considered to play a more subordinate rôle in the vital processes). But, he considers this chemistry as inadequate for explaining vital functions since "the determination and persistence with which living organisms will pursue and devour every bit of food material within reach and invade the entire earth's surface with their progeny shows that they must possess within the chemical structures of their tissues some contrivance which is definitely superior to ordinary chemical forces and which can function in a manner unknown to

chemical science. What is needed for this purpose is not some new form of molecule but some new type of chemical structure; not some new arrangement, but some new principle."

This new principle is assumed to be an arrangement of the amino-acid molecules in helical spirals which he terms *"spirazines."* He claims that these hypothetical structures are the cause of life because of their ability to combine with other peptid groupings of identical character, hence producing a process of assimilation leading to vital growth.

The concluding chapters deal with the application of the spirazine theory to the explanation of the make-up of living matter, to cell division, heredity and ontogenetic development.

The book contains, at the chapter headings, numerous quotations from famous scientists and philosophers such as Descartes, Newton, Lamarck, Claude Bernard, Haeckel and others, but the exact relationship of these rather general statements to the hypotheses explained in the text is not easy to see. Very few references to the literature are given. One of them relates to A. L. Herrera's work on "artificial cells," but it should be remembered that in this line of development everything is still rather uncertain.

In conclusion the reviewer wishes to voice his opinion that a great deal of ingenuity was necessary for the development of Krafft's biological hypotheses dealing with molecular structures of protein compounds *in vivo* and the further consequences of these ideas. It would seem desirable that his assumptions should be rendered amenable to experimental examination and to further application to fundamental biological problems.

R. Benton
University of Louisville

Jewish and Gentile Cancer

CANCER AND RACE, *by* Maurice Sorsby. William Wood & Co., N. Y., 1931.

IN this interestingly written book the question of cancer incident in Jews and Gentiles is analyzed and discussed.

The author maintains throughout a scholarly and scientific attitude. He recognizes at the outset certain fundamental but unavoidable sources of uncertainty in the data which he presents. Among these are "lack of uniformity in the published data," "local conditions frequently colour statistical data to no inconsiderable extent," . "Jews . . . do not lend themselves very well to statistical examination," and the fact that "countries vary greatly in their cancer mortality."

Part I deals with the incidence of cancer among Jews. London, Amsterdam, Vienna, Budapest, Warsaw, Lodz and Leningrad are considered in separate sections. The author concludes that the incidence of cancer varies greatly with the different communities. In London and Warsaw the total incidence in Jews and non-Jews appears to be approximately equal. In Amsterdam, Budapest and Lodz the rate for Jews is lower, while in Leningrad it is higher. Vienna shows a changing rate. He also notes the fact that the rates for Jews and non-Jews are closer in a given city than are those for Jews alone when different cities are compared. This, of course, is a clear indication that lumping or combination of data for different cities is a dubious statistical procedure.

In studying the distribution of cancer according to sex, the same division of data by cities is again followed. Summarized, the results seem to show in London, Budapest, and Warsaw an excess of cancer in Jewish women as compared with that in Jewish men, which follows roughly a similar distribution in non-Jews. In Amsterdam, Vienna, and Lodz no significant difference between the sexes is noted in either Jews or non-Jews.

The incidence of cancer according to the organ affected is next considered.

Such differences as exist in cancer of the alimentary tract suggest that Jews may show a higher incidence. The opposite seems to be true for cancer of the buccal cavity. In ovarian cancer the Jews again appear to be higher. There is no significant difference in the incidence of breast cancer.

"A remarkably lower rate for uterine cancer is recorded for the Jews in all the cities investigated." It is only from one-half to one-third that of non-Jews.

Cancer of the penis is absent in Jews in so far as available data from the cities in question are concerned.

Part II is in the nature of a general discussion. Its special emphasis is the problem of a specific racial factor in cancer. The author feels that "the greater part of the discrepancies between the distribution of cancer by organ as seen in Jews and non-Jews finds its explanation in the mode of life led by the Jews."

In general, on the basis of the data here offered, the reader will certainly have to agree that the factor which the author chooses to emphasize is certainly present. This fact obviously introduces a second variable to add to that of "race." Until data are collected from other sources and we are able to study cancer incidence in those of Jewish descent who do not follow the Jewish "mode of life" we shall not be able to distinguish between the two variables. The accurate evaluation of their importance is thus postponed for the present.

C. C. Little

Bar Harbor, Me.

Barnard Trustees on Motherhood and Careers

THE report of the Dean of Barnard College for the period ending June 30, 1932, contains a statement concerning college action on a problem that has puzzled many administrative groups. We quote from the report: "One of the most perplexing problems thrust upon women by the economic and social changes of recent years has been the necessity of combining marriage, motherhood, and careers. Partly because of our location in a great city and our connection with a large university where careers for husbands were conveniently at hand, Barnard has for many years had married women on its teaching staff. Recently, when the question of children arose, the President and the Trustees in several special cases arranged for the mother, when the birth of a child was expected, a half-year's leave of absence with full pay.

"It has seemed desirable to the Trustees to decide whether such a policy is a reasonable one and if so to regularize the practice. Accordingly a special committee of the Board was appointed to study the question, and on its recommendation the following resolution was adopted at the Annual Meeting of the Trustees in December:

> Resolved, That a woman member of the administrative or instructional staff of Barnard College, on Trustee appointment for full time, who is expecting a child, be granted a leave of absence for a half year on full salary or for a full year on half salary, the period of the leave to be determined by the Dean after consultation with the individual concerned.

"The administration is much gratified by this enlightened and progressive action. We have felt for many years that a woman's college was a peculiarly appropriate place in which to experiment with solutions of the new problems faced by women, and to attempt to arrive at some wise adjustment. Our observations have shown that the combination of rearing children and carrying on college teaching is a difficult one, but in some cases certainly very desirable. It is of the greatest importance that our teachers should be normal and interesting human beings, with as full and rich lives as may be. Neither the men nor the women on our staff should be forced into celibacy, and cut off from the great source of experience, of joy, sorrow and wisdom, which marriage and parenthood offer."

The Trustees should be congratulated on thus maintaining the college reputation for progressive thought and action.

Journal of Social Hygiene

REARED APART SINCE INFANCY

Figure 10

Again fate tries an experiment in the effect of rural and urban environments on an identical genetic constitution. Raymond (at right) was adopted by a well-to-do physician in a large city, Richard by a truck farmer in Southern Illinois. The rather slight differences brought to light by these tests are in favor of the twin who has had the harder, more varied, and "less favorable" environment. The photograph was made when the twins were ten years old. At thirteen they are still as closely alike as identical twins reared together.

MENTAL AND PHYSICAL TRAITS OF IDENTICAL TWINS REARED APART

Case VII. Twins Richard and Raymond

H. H. NEWMAN
The University of Chicago

THIS report deals with the youngest pair of separated twins in our series. When examined they were 13½ years old. These twin boys were born in Indiana to parents of middle European extraction, who were hard-working, honest and thoroughly respectable. They already had as many (or more) children as they could support when the twins were born. Against the parents' desires they consented to the adoption of the twins by two unrelated families. Richard was adopted when one month old, Raymond when fourteen months old.

Raymond was given a home in the family of a well-to-do physician in a large Indiana city and has had many advantages incident to such a home. Richard's foster father is at present a truck farmer living near a small southern Illinois mining town. He has lived in several different places, including a short period in Chicago, since Richard was adopted. From what I am able to learn from Raymond's foster parents, Richard's home life has been one of ups and downs, chiefly downs, but he has one very important home asset, an excellent mother. Neither of his foster parents has had much education.

Both boys have had the same amount of schooling, and at the time we studied them they were both in the eighth grade. They both have the reputation in school of being very alert and interested in their studies. About once a year the boys have been together for a day or so in Raymond's home, and during these brief associations have seemed very fond of each other and always liked to do the same things.

There have been no foster brothers or sisters at all near the twins' age, in either of the foster families. Raymond has two foster sisters, both much older than he. Richard is the only child in the family. Members of Raymond's family claim that the environmental differences in the two homes have been very marked and very much in favor of Raymond, but it seems to us that there are some advantages for Richard in having had a much more varied and changing social environment. He has also had to do much more for himself than has Raymond, who has always had a great deal done for him.

Proof of Monozygosity

It seems hardly necessary to enter into an elaborate proof of monozygosity for this pair. The photograph of them at ten years (Figure 10) shows them to be typical identical twins. The only real physical difference between them that we could find is that one of Raymond's legs is a little shorter than the other as the result of a cartilage infection in the knee. Table I gives their physical characteristics, etc., and emphasizes their close resemblance. In nearly all respects Richard is a size larger, but identical twins reared together commonly show differences of about the same degree.

The finger print formulae are as follows:

RICHARD

Left hand	*Right hand*
U. W. Wu. W. Wlu.	Wdu. W. Wu. W. Wlu.

RAYMOND

Wdu. W. Wu. W. Wlu.	Wdu. W. W. W. W.

All the fingers but the left thumb of Richard have whorls. The formulae of Richard's right and Raymond's left hand are the same. Also there are

more detailed resemblances between Richard's right and Raymond's left hand than between own right and left hand of either twin. The patterns of all four hands, however, are very similar.

The quantitative values, involving ridge counts of the digital patterns are as follows:

		Left	*Right*	*Total*
Newman Method	Richard	53	58	111
	Raymond	56	57	113
Bonnevie Method	Richard	42	46	88
	Raymond	46	45	91

According to the first method there is a difference of total values of only two points; according to the second method the difference is three points. One method shows slight mirror-imaging, the other does not. These differences in quantitative values are well below the average found in 50 pairs of identical twins reared together.

The formulae for the palm prints are as follows:

Richard (Left).. 9.7.5".H—tt"—Lr.O.O.O.L.
(Right) .....11.9.7. H—tt"—Lr.O.O.L.O.

Raymond (Left)....7.5".5".3— t —A^u.O.O.O.L.
(Right) .....9.7. 5".H—tt"—Lr.O.O.O.L.

Here Richard's left hand is almost identical with Raymond's right, whereas there are marked differences between Richard's left and his own right and between Raymond's right and his own left.

Thus both finger prints and palm patterns show the type of mirror imaging characteristic of so many identical twins. This mirror imaging is carried out in several other features. Thus Richard's right hand is broader than the left, while Raymond's left hand is broader than the right. Also Richard's left forearm is larger than his right, while Raymond's right is larger than his left. Both are now functionally right-handed and both have clockwise hair whorls. They are almost indistinguishable in hair color, eye color, shape of ears, shapes and condition of teeth, condition of skin, features, expression, and even in the distribution of small moles on the face.

Intelligence Tests

1. *Stanford-Binet Mental Test.*—The results of this test are as follows:

	Richard	*Raymond*
Mental Age.....	14 yrs., 4 mos	14 yrs., 2 mos.
I. Q.	106	105

These are very slight differences, considerably less, in fact, than the average differences in 50 pairs of identical twins reared together.

2. *Thurstone Psychological Examination.*—This test, designed as it is for high-school graduates and freshmen in college, was naturally too difficult for these boys, yet they did better than some freshmen. The results are as follows:

	Total Score	*Percentile Rank*
Richard	58	4
Raymond	43	3
Difference	15	1

Richard again scored slightly higher than Raymond, but the difference is not considered very significant, since there is a difference of only one place in percentile rank.

3. *International Group Intelligence Test (non-verbal).*—Here the total difference was a little greater. Richard's score was 140 and Raymond's 126, a difference of 14, a significant difference; and the difference is in the same direction as in the first and second tests.

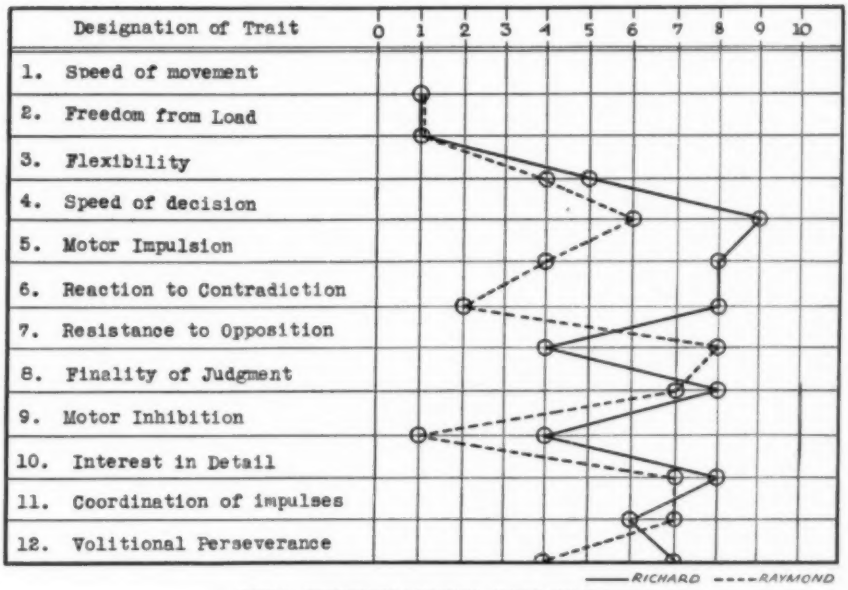
4. *Otis Higher Examination.*—This test is also designed for high-school and college students. The results were:

	Score	*Mental Age*	*Index of Brightness*
Raymond ..	36	15 yrs.,	115—Normal
Richard	31	13 yrs., 10 mos.	74—Normal

Here there was a difference of 14 months in mental age in favor of Raymond, a difference that tends to balance the superiority of Richard in the previous tests.

5. *Sanford Achievement Test.*—The results are as follows:

	Total Average Score	*Age Equivalent*	*Grade Equivalent*
Raymond	102.0	15 yrs., 11 mos.	10.0
Richard	101.3	15 yrs., 9 mos.	9.8
Differences	0.7	2 mos.	0.2



WILL-TEMPERAMENT "PROFILE"

Figure 11

Considerable differences in temperament are indicated by the Downey-Will temperament Test, the results of which are diagrammed here. Richard, perhaps because he has had a less protected life, is the more positive and aggressive.

The differences here are once more very slight, and probably not significant, but they are in favor of Raymond.

Summary of Intelligence Tests.—The results of all five tests show that Richard and Raymond are approximately equal, what little difference there is being slightly in favor of Richard, the twin with the supposedly less favorable home environment.

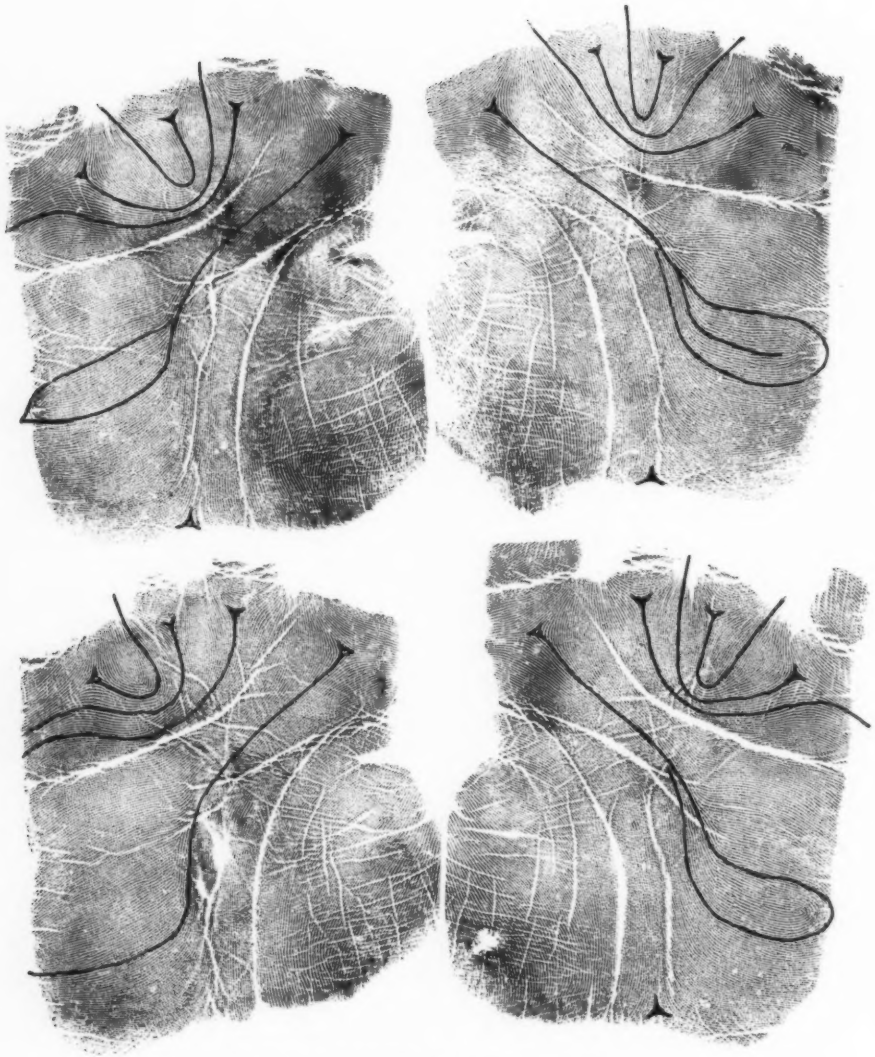
Temperament—Emotional Tests

6. *Woodworth Mathews' Personal Data Sheet.*—Raymond gave 14 unfavorable answers, Richard 12. Four of these answers are the same for both. This seems to indicate that their nervous balance is about the same, but that the items that disturb one are somewhat different from those that disturb the other. No really significant difference in temperament is indicated by this test.

7. *Pressy X-O Test of Emotional Reactions.*—In this test the differences were somewhat greater, but the difference was marked only in one of the elements of Test I, which tests reactions to unpleasant words. The scores on this test were as follows:

	Raymond	*Richard*
Disgust	16	11
Fear	9	5
Sex	9	2
Self-feeling	12	10
Total	46	28

These differences are the only ones found that seem to reflect rather definitely the differences in home life of the two boys. Richard has seen more of the seamy side of life and is less adversely affected by suggestions of fear and sex than is Raymond, who has rarely been away from his rather refined and sheltered home.



PALM PRINTS OF THE TWINS

Figure 12

The palm print formulae are given in the text. All four patterns are quite remarkably alike. The most striking resemblance is between Richard's left palm (upper left) and Raymond's right (lower right). The formulae which describe the patterns of these two hands are identical. This is a typical example of the mirror image resemblances that are found so often in identical twins.

8. *Downey Will-Temperament Test.*—In this test Richard had a total score of 69, Raymond of 52. This difference of 17 points is too high to be overlooked and shows some real difference in temperament. The greatest differences are in motor impulsion and reaction to contradiction, where Richard is distinctly superior, and in resistance to opposition, where Raymond is superior. There seems to be no question but that Richard is the more positive, more aggressive of the twins. This is doubtless the result of his somewhat greater contact with the difficulties of life. It is quite possible that later on, when the occasion demands, Raymond will toughen up in his reactions. The graphic details of this test are given in Figure 11.

9. *Kent-Rosanoff Association Test.* Rather curious differences between the two boys appeared in a number of items in this test. Richard gave only 13 unusual responses, while Raymond gave 69. The average frequency of response for Richard was 214, and that for Raymond 61. These represent, if genuine natural reactions, very large differences in temperament. At present we do not understand the significance of these great differences. Personally, I am inclined to suspect that Raymond was getting tired of tests and tried to be funny at our expense, for a very large number of his responses indicate associations so unusual that they do not appear in the authors' table of common responses. Also there seems to be no imaginable connection between many of his paired words. Some of the worst of these were: "sickness-shoe," "soft-building," "eating-paper," "mutton-bulb," "fruit-girls," "smooth-spine," "sweet-door," and so on.

Either Raymond had a mild brainstorm during this test or he possesses a peculiar temperament. We are at present arranging for these twins to be examined by a psychiatrist in order to determine, if possible, how real the temperament-emotional differences are.

Dr. Freeman is frankly puzzled about this test, but is inclined to think that the "test indicates a marked qualitative difference in the mental processes of the two boys."

Summary of Temperament-Emotional Tests.—The evidences are clear, I believe, that the boys differ rather decidedly in temperament, but that the differences are not as yet to be taken at face value. The boys are perhaps a little too young to take these tests quite seriously, and there are some indications that Raymond took them less seriously than Richard.

Association with the boys impressed the examiners with the fact that Richard is distinctly more aggressive and more positive in his reactions. At

TABLE I—Physical Characteristics

	Richard	*Raymond*
Height	144.4 cm.	141.5 cm.
Weight	86.5 lbs.	86.0 lbs.
Circumference right calf	46.1 cm.	46.0 cm.
Circumference left calf	46.2 cm.	44.0 cm.
Width of right hand	7.7 cm.	7.4 cm.
Width of left hand	7.4 cm.	
Head length	17.3 cm.	17.3 cm.
Head width	14.4 cm.	14.4 cm.
Head girth	51.9 cm.	51.9 cm.
Hair whorl	Clockwise on right side	Clockwise near middle
Teeth	Lower hight first and second molars decayed	Same
Ears	Both of Raymond's and Richard's right alike, Richard's left a little different in form	
Eyes	Slate gray	Same
Hair color	Medium brown	Same
Hair texture	Straight and moderately fine	Same
Handedness	Right-handed	Same

present he certainly seems to have the stronger personality. I would then class this pair as moderately different temperamentally, equal intellectually, and almost equal physically.

Conclusion

The only effective environmental difference has been one in social milieu. Richard has had a more varied and harder life than Raymond. This seems to have brought out in him some of the more positive traits of character that as yet are relatively undeveloped in Raymond. These twins show on the whole less extensive differences than any pair in the series thus far reported. This may be due partly to the fact that they are considerably younger than any of the others with less time in which to have grown different, and partly to the fact that the environmental differences encountered by them have not been very great.

Social Progress in Review

THE TECHNIQUE OF SOCIAL PROGRESS, *by* HORNELL HART. Pp. xv+708. Henry Holt & Co., 1931.

DR. HART'S substantial volume, The Technique of Social Progress, is intended as a textbook for an orientation course in the social sciences. Its central theme is the development of human culture. As is shown in the introductory chapter, progress is a subject about which writers on social phenomena entertain the widest possible variety of opinions, some holding that "progress is inevitable," and that we are destined to go on steadily towards perfection, eventually arriving at some kind of a millenium, whereas others are prophets of despair and look forward to a period of decadence out of which we may or may not rise.

The second chapter on Racial Progress and Regress deals briefly with man's biological evolution, both past and present, with comments on the present dysgenic propagation of the race. The great bulk of the volume is devoted to discussions of diffusion versus parallelism, the development of technology, changes in the scale of living, the cultivation of the arts and sciences, the evolution of religion, changes in domestic relationships, and the development of economic and political institutions. At the close of each chapter there are questions for thought and discussion, and reference assignments for various classes of students, so that a choice may be made of the more appealing topics. It is impossible to convey an adequate idea of the rich contents of this volume in a short review. If the student does a quarter of the work that is laid out for him he should have a pretty fair introduction to to the social sciences.

S. J. HOLMES.

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OF
CREATIVE EVOLUTION

By C. C. HURST

Doctor of Philosophy of the University of Cambridge
Author of *Experiments in Genetics*

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